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NOTICE TO AUTHORS OF PAPERS

1. Forwarding Address. Papers intended for publication in THIS JOURNAL should be submitted to Neil E. Gordon, Editor, The Johns Hopkins University, Baltimore, Maryland.

2. Manuscript. The manuscript submitted should be an original (not a carbon) copy, and typewritten, double-spaced, with 2–3 cm. margins. The title of the article should be followed by the name and address of the author. If the paper has been presented at a meeting, a footnote giving name of society, date, and occasion should immediately follow the author's name. The usual editorial customs, as exemplified in the most recent issues of the JOURNAL, should be followed as closely as possible.

3. References and Footnotes. Each reference to the literature and each footnote should be inserted without a number, as a separate line (or lines) immediately following the word to which it refers in the text. A reference to literature should include, in the order named, the title of book or article, author's name, edition or volume, pages, date of publication, and, in the case of books, publisher's name.

4. Illustrations. Not all articles lend themselves to illustrations, but articles which do should be accompanied by as many pertinent illustrations as possible. As a rule, apparatus, particularly if complicated, is best presented by means of line or working drawings. Photographs are sometimes sufficient, however. When both can be obtained, it is generally desirable to include both.

Photographs should have a gloss finish and should be at least post-card size—larger, if possible. Only prints which are unblurred and which show sharp contrast between light and dark areas can be satisfactorily reproduced.

Line drawings should be carefully prepared on plain white drawing paper or blue drawing cloth, twice or three times the size desired in the printed cut; it is convenient, when permitted by the scale required, to have them the size of the manuscript. When coördinate paper is used, it should be printed in blue only, with the important coördinate lines ruled over in black; the black square should in general not be less than ten millimeters on a side; the lines of the curves should be the heaviest, except the frame; points on the curves should be indicated by true circles, not crosses. The numbering of the coördinate axes, the number of the figure and any necessary explanations of the figure should be written in pencil in the margin of the sheet, as they are usually set up in type rather than reproduced from the drawing. All lines, numbers, and letters that are to be reproduced are to be so proportioned that they will be clearly legible in the cut.

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EDWARD WILLIAMS MORLEY

EDITOR'S OUTLOOK

YOU will remember that Zola once said of Debat-Pousan, "Ah! that man is more than a great painter, he is a fine character who has become a great painter; and it is because he is a fine character that great genius has come to him. What a lesson for artists who fail to put their manhood first!" And perhaps what holds for artists is true of scientists as well. For Edward Williams Morley falls into the category of noble characters and also of scientific geniuses.

Edward Williams Morley

He is probably best known for his work in collaboration with Prof. Albert A. Michelson on the velocity of light (1886–1889). The most important of his works, however, was his determination of the densities of oxygen and hydrogen and the ratio in which they combine. This took him from 1882 until 1895, when the final result was accepted for publication by the Smithsonian Institution. The *Zeitschrift für physikalische Chemie* also published it. This more than any other single work spread his fame as a scientist. Says Dr. Tower, in the *Western Reserve University Bulletin:*

"In it one sees his remarkable insight into the fundamental nature of the problem, his great skill in devising and manipulating apparatus, his precision of measurement, and his great patience and perseverance in overcoming obstacles at times seemingly unsurmountable."

It seems strange that so famous a scientist should have been destined by his family for the ministry or that one who was in middle life the possessor of such rare stores of energy should have started life as a very sickly child. He was born in Newark, New Jersey, on January 29, 1838, graduated from Williams College in 1860 and from Andover Theological Seminary in 1864.

In 1866, he read his first paper on science before the American Association for the Advancement of Science. His subject was the latitude of the Williams College Observatory. By 1868, he felt sufficiently strong to take up ministerial duties and was offered a church at Twinsburg, Ohio. At the same time, however, the Western Reserve College at Hudson offered him a professorship of natural history and chemistry. He accepted the latter. From the first his chief interest was in chemistry, though he is declared to have been capable of mastering all the physical sciences. In physics, especially, he did some very important work, the most noted being his development with Prof. Michelson of the interferometer for measuring lengths in terms of the wave-length of light, and his construction of a manometer, which could measure differences of gaseous pressure as small as one ten-thousandth millimeter of mercury.

We feel warmed toward the man when we hear that he would travel

back and forth from the third floor of the building, where his classes were held, to the basement where he conducted his research, supervising a class in quantitative analysis and working out one of his own difficult experiments at the same time. But step into his lecture room a minute and learn more of this earnest worker. He not only required that his students know the principles of chemistry, but he demanded that they have good manners and that they express themselves clearly and well. "In a word" (we quote again from Dr. Towers), "he made a course in general chemistry a liberal education in itself."

He retired from Western Reserve University (which had moved to Cleveland and assumed the name of Adelbert College of Western Reserve University) in 1906. He went to live in West Hartford, Connecticut, where he still carried on experiments in a laboratory he had built himself. Besides that, he walked a little, drove about in his car, grew a great many gladioli in his garden and continued to take an active interest in things musical. His wife, whom he married in 1866, died near the close of the year 1922. He himself died just a few months later on February 24, 1923, victim of an operation which, though not in itself serious, was followed by unexpected complications. Both he and his wife were buried in Pittsfield, Massachusetts.

Though truly eminent, Morley was little known, except among his fellow scientists, because of his extreme modesty, and his shyness in the presence of strangers. The list of honors which came to him is too long to quote here. We shall mention only a few. He was at one time president of the American Association for the Advancement of Science and also of the American Chemical Society. He was an honorary member of the Royal Institution of London, a foreign member of the Chemical Society of London, and a corresponding member of the British Association for the Advancement of Science.

Such men are rare jewels in any nation's crown. Shall we agree with Zola that "it is because he was a great character that great genius has come to him?"

The Superior Student

THE post-war inflation of student bodies in American colleges has stimulated an unprecedented interest in educational problems. The general tone of this lately increased concern over educational affairs has been rather critical than otherwise. No constant reader of our more serious and dignified periodicals can escape the impression that higher education in these United States is susceptible of some degree of improvement.

It is hard to say just how many of the real and fancied ills of our colleges and universities are directly attributable to involuntary expansion,

how many have been merely aggravated or magnified by that phenomenon, and how many have been discovered or imagined because of the universal growth of interest in such matters. We believe, however, that two problems are fairly general, and that they may be somewhat related one to the other—in solution if not in origin. These are: first, the necessity of meeting greatly increased obligations out of income which has increased but slightly in comparison, and second, the desirability of some satisfactory means of dealing fairly, but differently, with the exceptionally promising and the mediocre student.

The nature of the measures to be recommended must depend to some extent upon the philosophy of education adopted. Something resembling the old *status quo* might be approached by raising entrance requirements and tuition fees in opposition to the increased effective demand for higher education. Such a course, though not often openly advocated, would apparently find favor in some quarters. It is, however, diametrically opposed to American ideas and ideals. As a nation we have maintained, theoretically at least, the desirability of universal education and of equality of educational opportunity. Least of all would we be disposed to set up financial barriers in the way of aspiring students.

After all, the rapid increase in the demand for higher education has been almost purely an economic phenomenon. As national wealth has increased, private endowments and public appropriations to educational institutions have operated to decrease the proportion of the actual cost of education which must be borne by the student or his parents. At the same time the average annual income per family has increased, so that more families than ever before are able to meet the expense of maintaining one or more children at college. There is no convincing testimony to show that college entrants of today are less able or less likely as a group to derive benefit from college training than those of fifteen years ago. There seems to be but slight correlation between parental means and educability on the part of the student. On the whole the requirements both for college entrance and for college degrees are higher now than they were a decade ago. The statistical indications are that a new equilibrium is approaching. Student bodies are no longer expanding at the rate of a few years ago. The educational plant is in a fair way to catch up with the demands upon it.

The question therefore arises whether in the catching-up process it is not both desirable and possible to do something about the problem of the superior and the mediocre student. Would it not be more just to the student as well as more profitable to the nation at large to expend more means and effort upon the more promising student than upon his less gifted or less industrious brother?

Attempts to free the superior student from the drag attached to him

by the slower progress of his mediocre classmates have in general taken one of two forms. He may be trained more extensively and thoroughly in the time allotted by the standard curriculum or he may be allowed to proceed through the customary course at a greater rate of speed. On the whole, the latter plan seems to work more satisfactorily in practice. By choosing schools and universities where this plan is in operation, the exceptional student may now lop some two or more years from the time ordinarily considered as normal for the progress from the first grade to the Ph.D. In so doing, he actually costs the community considerably less than the average student.

It has been suggested that one means of securing a more equitable distribution of educational expenditure and of insuring that a greater number of gifted students might be financially able to complete their educations would be to subsidize youths of unusual attainment and promise. This could be done through the establishment of scholarships similar to the state scholarships available in many European universities. Such scholarships would be particularly effective if they could be made generally available to outstanding students during their last two years of undergraduate work and throughout their graduate training. It is at the beginning of this period that the student must usually make tentative choice of a career and it is precisely at that time that immediate financial considerations are apt to exert an undue influence upon his choice. Dr. S. R. Williams[1] and Dr. R. A. Gortner[2] have already called attention in *Science* to the regrettable loss of promising scientific personnel through economic pressure, and have urged that some means of remedying the situation be found.

One of the experiments to be carried on by the newly founded Chair of Chemical Education at the Johns Hopkins University will consist in putting a similar suggestion to trial. The system of fellowships described in the note beginning on page 319 of this number is admirably adapted to that purpose. It should go a long way toward answering two questions which need to be answered: first—Is it possible to attain a high degree of reliability in the selection of students of unusual ability and potential worth?—and second—Is it profitable from the standpoint of society at large to subsidize them? If it should be that both of these questions receive affirmative answers, it is to be hoped that legislatures and donors of endowments will see fit to provide that the practice shall become general throughout the nation.

[1] *Science*, **68**, 244–5 (Sept. 14, 1928).
[2] *Ibid.*, **68**, 402–3 (Oct. 26, 1928).

WHAT A CHEMIST MAY SEE IN EUROPE

RALPH E. OESPER, UNIVERSITY OF CINCINNATI, CINCINNATI, OHIO

What is the use of travel, I asked myself. The stars are as near to London as they are to the Spanish Main. In their planetary journey through the void the passengers at Peckham see as much as their fellows who peer through the windows at Macassar. The sun rises in the east, and the moon is horned; but some of the passengers on the mud ball strangely enough take their tea with milk. Yet what of it?

Tomlinson: "The Sea and the Jungle."

European travel has long been recognized as a potent educational factor by those whose professional or academic interests are concerned with art, music, architecture, literature, history, etc., while the students, teachers, and practitioners of chemistry have laid relatively little stress on the value of European travel to them. The so-called cultural branches find in Europe the external manifestations of their subjects—such as great pictures, highly developed opera, notable buildings, literary shrines, historic places —while the master-pieces of science are for the most part displayed within the pages of standard textbooks and journals readily available on both sides of the Atlantic. Scenery, artistic masterpieces, and historic places have an appeal to all classes of educated persons for each one of these has at least a superficial acquaintance with history, art, and literature and, consequently, a natural desire to see at first hand the things which he has been taught to regard as essentials of a complete education. The writer has no desire to enter into a controversy as to what constitutes real culture, but he is firmly convinced that the relative neglect of the educational value of European travel, in which emphasis is laid on things scientific rather than on old churches, art galleries, and battlefields, is not only greatly to be deplored, but is also an indictment against the impersonal presentation of the sciences in our schools.

It is of prime importance to know what has been done, but it adds immensely if we also know how, and where, and why, and by whom certain results have been achieved. It is possible to know much English history without visiting England, or much of Goethe without seeing Weimar, or much of Italian Art without a stay in Florence. But is this course to be recommended, even to students of science? Who can deny that the work of Liebig will not be endowed with far greater significance after a visit to Giessen and an inspection of his modest laboratory and meager equipment? Should not the names which our students so glibly attach to reactions and laws be something more than convenient labels? Too long have we neglected to humanize our subject matter, and the history of chemistry must necessarily remain relatively abstract until our students and teachers have stood on "holy ground." Other pastures make fatter calves and travel broadens the intellect. If we can cover the bare

bones of fact with the flesh of historic background and clothe the body with a raiment of personal acquaintance with the birthplaces of our well-known laws and reactions, then our teaching will indeed become vitalized. Students, like all mankind, are interested in personalities, and the recital of what has actually been seen goes far to convince them that these are not simply tales that are told.

A visit to a battlefield means little to one not versed in history; the examination of a great cathedral does not reveal much to the ordinary tourist; an inspection of the workroom of a noted painter has no thrills for him not versed in art, but what a wealth of information and inspiration is carried away by one who comes with seeing eyes. As Thoreau said, "There is no use in going around the world to count the cats in Zanzibar." Competent guidance or adequate preparation are always essential to full appreciation. Some may claim that all laboratories are built after the same pattern and this is true in the sense that all cities are made up of houses set along streets, but to the informed visitor each tells its story, both material and historical. The European laboratories, like those in our country, vary in age, excellence of design and equipment, but in each something of interest and information may be found, provided we can see beyond the table tops and reagent bottles. Age in a religious edifice is often a virtue, while in a laboratory it frequently is a very doubtful asset. The laboratories in which chemical history has been made are often old-fashioned and lack modern facilities, but the chemical tourist can mentally re-people them with the great ones who have there added to our science and see for himself how important results are often achieved with scanty equipment amid barren surroundings. The modern European laboratories are not strikingly different from the newer American ones, but each has points of special interest, and if visited while in actual use much pedagogical information may be acquired. On the continent particularly, the lectures in general chemistry are illustrated with a wealth of demonstration material.

The historians of science are realizing more and more that technical museums are the proper places for preserving scientific relics. Those in charge of such institutions have a professional interest in the collection and care of apparatus with which scientific triumphs have been won. The main business of the laboratories is along totally different lines with the natural result that such material is often neglected, scattered, and eventually lost. In discussing technical museums, van't Hoff said:

> It is perhaps proper to compare art galleries with museums devoted to science and technology. The contents of an art gallery, if properly chosen, have a value which increases as time goes on; in this sense an art museum is *a priori* a profitable undertaking. On the other hand, historical apparatus, even that which was used in the most important scientific and technological discoveries, does not share this fate. Such ma-

terial grows increasingly old-fashioned and eventually becomes a mere curiosity. Likewise, these two types of museums are directly opposed as regards the interest of the general public, whose regular patronage, in the last analysis, determines the usefulness of such collections. A work of art may be enjoyed by anyone, even without special training; a scientific or technologic exhibit, however, must be understood if it is to arouse interest.

The cultivation of the historic interest is the special province of such museums, and the material may be vitalized and made understandable by well-arranged exhibits, working models, lectures, etc. The relation of pure and applied science can nowhere else be demonstrated so well. Such museums are to be found in Europe and the information to be gleaned from them is of great value, particularly to Americans, for our scientific youthfulness has hindered us in the building up of collections of this kind.

The cemeteries also have an interest, for why should we not pay respectful visits to the last resting places of the chemical aristocracy? Certainly the graves of Davy, Liebig, and Gay-Lussac have more to say to a chemist than the oft-visited tombs of the departed captains and kings who, in many cases, brought little but suffering into this world. No special comment is necessary regarding the interest and value of meeting the living leaders of chemical thought.

Although teachers and students will derive most interest, inspiration, and information from the universities and museums, the industrial chemist, will, of course, welcome the opportunity of visiting chemical plants. The conditions governing such visits hold throughout the world and should not be forgotten. Competitors are usually not welcome, but those whose interests are academic can frequently secure admission if they will present, beforehand, letters of introduction. The commercial attachés in the various embassies and legations and, likewise, the university professors can be very helpful in this respect. A professional visiting card is of inestimable value and teachers, especially, should provide themselves with a liberal supply of these, stating position, degrees, etc. Human nature is much the same throughout the world. The serious chemical tourist will be pleasantly surprised at the cordial welcome he will receive in most instances, and if he does his part, he will soon learn that the term chemical fraternity is no misnomer. The language barriers may sometimes seem insuperable, for surprisingly few of the continental chemists possess anything beyond a reading knowledge of English. However, with special efforts, and tolerance on both sides, conversations are possible, for we are dealing with cultured people. *C'est l'ignorance qui separe les hommes, et la science qui les approche.* (Pasteur.)

The information given hereafter makes no claims of completeness, but is merely suggestive of what the writer and others have found of interest. The standard guidebooks are sadly lacking from the scientific standpoint.

The chemical Baedeker is still to be written and there is real need for a compilation of this kind. Tastes differ and each must choose for himself the phase of European chemistry he wishes to emphasize. It is hoped that what appears below may aid in this choice.

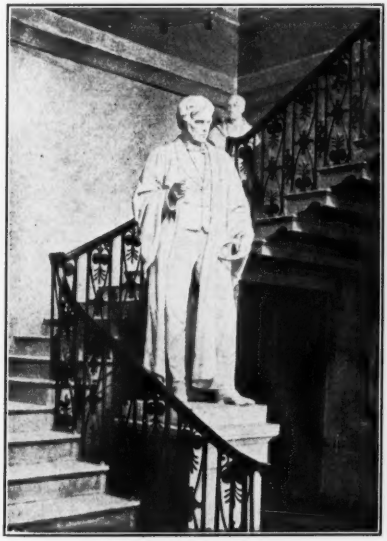
Great Britain and Ireland

As might be expected, there is much of interest to the chemical tourist in London, so that a stay of at least two weeks is required to see all its

THE ROYAL INSTITUTION BUILDINGS. THE DAVY-FARADAY RESEARCH LABORATORY
This Institution was founded in London by Count Rumford in 1799.

scientific sights. The Royal Society, or Academy of Science, founded in 1660, is of particular interest because of its association with the greatest of English scientists. The library with its rare volumes, portraits, and relics, particularly of Newton and Cavendish is especially attractive. Close by are the headquarters of the Chemical Society of London. The library of about 30,000 volumes is the greatest chemical collection extant, and is very rich in periodicals. Its facilities are available to visiting chemists. The old and the new are united in the Royal Institution, founded in 1799 by the American, Benjamin Thompson (Count Rumford). Its ob-

jects are "the promotion, diffusion and extension of science and useful knowledge" and these aims have been accomplished through its research laboratories and popular lectures. At present about 60 lectures, dealing with all branches of science, are given each year between January and July. They are deservedly famous, not only for content, but for the well-planned demonstration material accompanying them. Admission to these and to the Friday evening meetings may be secured through the members. The course of juvenile lectures, attended mostly by adults, has long been an annual event at Christmastime. A list of the Professors of the Institution is sufficient to characterize the high standing of this foundation as a research center. In turn they were Young, Davy, Brande, Faraday,*[1] Frankland, Odling, Tyndall, Gladstone, Rayleigh, Dewar, J. J. Thomson, Rutherford. The Davy-Faraday Research Laboratory next door is affiliated with the Institution, and this modern laboratory is in charge of the present Professor Sir William H. Bragg. The main line of research is now x-ray and crystal structure. The historic laboratory of Davy and Faraday in the basement of the old building is shown, though it is now used as a storeroom. Interesting collections of historical apparatus and collections are on view and the visitor will also be shown the historic lecture room and remarkable library. The National Portrait Gallery contains an interesting picture "Eminent Men of Science Living in 1807–1808" showing them grouped in the library of the Institution.



STATUE OF MICHAEL FARADAY AT THE ROYAL INSTITUTION

Landsdowne House in Berkeley Square, has nothing of present interest to the chemist, but it was while living there as librarian that Priestley discovered oxygen. The town house of Cavendish at Montague Place and Gower Street is marked with a tablet. The Science Museum in South Kensington contains a remarkable collection of early machinery, models, scientific instruments, etc., in short, something representative of

* Numbers refer to pertinent articles which have appeared in THIS JOURNAL. References are listed at the end of the article.

THE BRITISH MUSEUM

In the library will be found many alchemical manuscripts. Numerous specimens of the chemical products of ancient peoples are also exhibited.

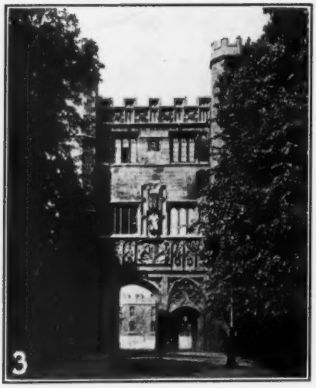
all branches of physical science or industry. The chemist will be particularly interested in the apparatus of Graham, Crookes, Kelvin, Joule, etc. The Natural History Museum, also in South Kensington, contains one of the world's finest collections of birds, beasts, insects, and plants. The War Museum close by shows applications of science to warfare. The Museum of Practical Geology in Jermyn Street, the Wellcome Historical Medical Museum in Wigmore Street, the Museum of the Royal College of Surgeons, Lincoln's Inn Fields, especially noteworthy for the specimens from the World War, can be highly recommended. The British Museum contains many specimens of the chemical products of ancient peoples and its library has many alchemical manuscripts.

The Government Chemical Laboratories, much like those of the Bureau of Chemistry in Washington, are located in Clement's Inn Passage, and the National Physical Laboratory, corresponding to our Bureau of Standards, is at Teddington, Middlesex, about 12 miles southwest of London. The famous Rothamsted Experimental Station is of interest to those engaged in agricultural chemistry. It is near St. Albans, Hertfordshire, 20 miles northwest of London. Other interesting places open to qualified visitors are: the Lister Institute of Preventative Medicine, Chelsea Bridge Road; the National Institute for Medical Research, Mount Vernon Road, Hampstead; and the Institute of Hygiene and Tropical Medicine, Bloomsbury. The Observatory at Greenwich and the Royal Astronomical Society have general scientific interest. The rooms of the latter contain a piece of the famous apple tree. Faraday's grave is in Highgate Cemetery, while Newton and Kelvin are buried in Westminster Abbey.

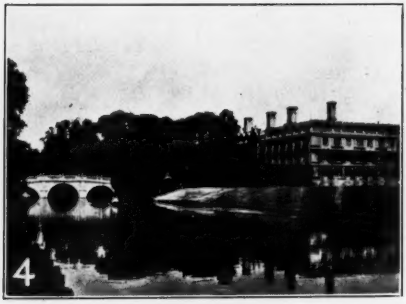
The University of London consists of numerous colleges scattered throughout the city. Only two of them have chemical laboratories worthy of note. The quarters assigned to chemistry at King's College in the Strand are very old and inadequate, but a new laboratory is announced for the near future. The museum contains apparatus used by Daniell, Faraday, and Wheatstone. University College[2] in Gower Street has excellent equipment and quarters. Much of Ramsay's work was done here, and specimens of his apparatus may be seen. Those in charge are F. G. Donnan[3] (physical), J. N. Collie (organic), and J. C. Drummond (biochemistry). The Ramsay Memorial Laboratory of Chemical Engineering is close by. The laboratories of the Imperial College of Science and Technology, in South Kensington, are modern. Among those teaching there are J. F. Thorpe (organic), J. R. Partington (mathematical chemistry), and H. B. Baker (physical). The laboratory of fuel technology, in charge of W. A. Bone, is especially noteworthy.

Chemistry is actively pursued at many of the provincial British universities. At Cambridge are such authorities as W. J. Pope, E. K. Rideal,

W. B. Hardy, F. G. Hopkins, etc. Every chemist, of course, will visit the Cavendish Physical Laboratory, which at present has the unique distinction of housing four Nobel Prize recipients: J. J. Thomson, E. Rutherford, F. W. Aston, and C. T. R. Wilson. At Oxford W. H. Perkin, H. B. Hartley, F. Soddy, and N. V. Sidgwick are active. Manchester is of particular interest because of Dalton's long residence there, and his statue



VIEWS OF CAMBRIDGE

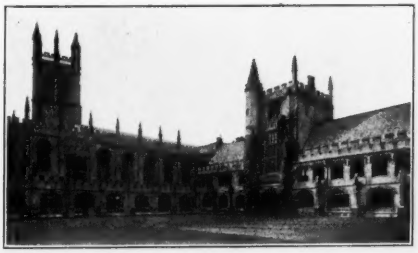


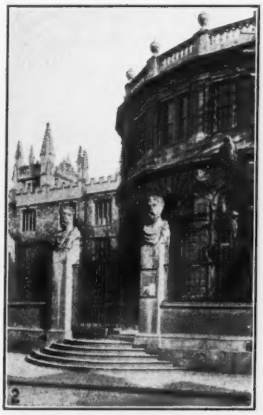
1. Front of King's College.
2. St. John's College, Chapel Tower.
3. Trinity College Gateway.
4. Clare College and Bridge.

in the university and his grave in Ardwick Green Cemetery should be seen.[4] The University has an excellent fuel laboratory and the textile institute is first class. Among those teaching there are A. Lapworth and H. B. Dixson. Leeds was the former home of Priestley and many of his researches on "airs" were made there. Good metallurgical work is carried on at the university and the tanning school is excellent. Good chemical work is also done at Sheffield and at Liverpool (C. C. Baly, W. C. McC.

Lewis). In the years following 1780 a group composed of James Watt, Erasmus Darwin, and Joseph Priestley[5] met regularly in Birmingham to discuss the scientific advances of the times. Priestley's house here was burned by a mob in 1791.

Principal Sir J. C. Irvine, of St. Andrews, the noted authority on sugars, furnishes the following information relative to the Scotch universities:

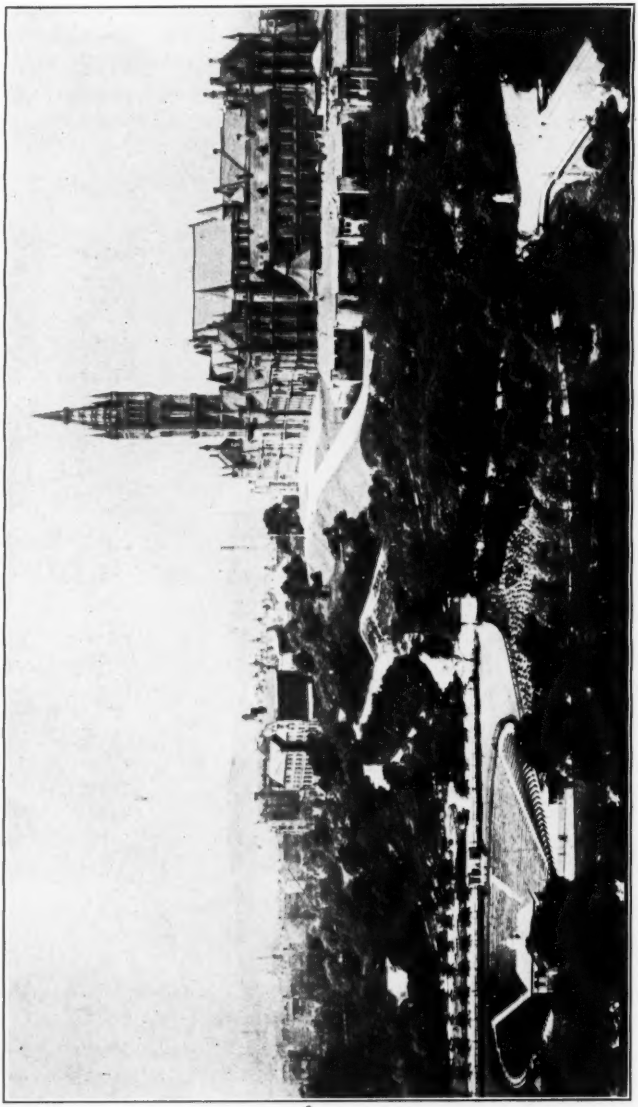




VIEWS OF OXFORD

1. The Cloisters, Magdalen College.
2. The Sheldonian Theater.
3. The Radcliffe Camera.
4. The Twin Towers, All Souls College.

"The educational aspects of chemistry are conveniently localized and the four Scottish Universities (St. Andrews, Glasgow, Aberdeen, and Edinburgh) are easily reached from Edinburgh as a center. The new laboratories of the University of Edinburgh[6] (James Kendall) situated at the King's buildings, are reminiscent of the Sterling Laboratory at Yale, and the organization is interesting in view of the differentiation between chemistry for students of general science, for applied science, and for medi-



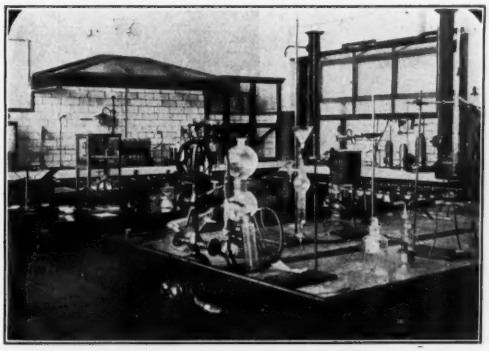
UNIVERSITY AND KELVINGROVE, GLASGOW

cine. The educational problem of Glasgow (G. G. Henderson) is for the time being focused on the difficulty of handling large numbers of students and the situation, which is in some ways similar to that encountered at Columbia, will be of interest to many professors.

EDINBURGH UNIVERSITY, FROM THE QUADRANGLE

"St. Andrews (J. Read, J. C. Irvine) presents features which, from their novelty, make a special appeal to the American scientific visitor and it comes as a surprise to find a 20th century Research Laboratory thriving in a city of the 11th century. The equipment is excellent and the organization follows closely on the lines adopted by Theodore Richards at Harvard, as does that of the sister laboratory in Dundee. The Chemistry School of the University of Aberdeen (A. Findlay) is the most northern in the British Empire and its student material affords a good example of the soundness of the Scottish educational ladder leading from school to university."

Ireland has universities at Dublin, Galway, Cork, and Belfast. In Wales, universities are at Bangor, Swansea, and Cardiff.



INTERIOR OF IRVINE'S LABORATORY, ST. ANDREWS

The chemical laboratories of the British universities are closed during July, August, and September. Much useful information may be obtained from the American University Union, 50 Russell Square, London. The handbook issued by the Institute of International Education, 2 W. 45th St., New York, will also be found of value.

England is tremendously important as regards chemical manufacture. The following are typical of what may be seen.

London: Works of the Gas, Light, and Coke Company; Westminster Works of the South Metropolitan Gas Company, Old Kent Road. *Liverpool:* Works of Lever Brothers, Port Sunlight; Imperial Chemical Industries, Brunner, Mond & Company,

Underwood and Underwood

LIBRARY, TRINITY COLLEGE, DUBLIN
Some of the world's choicest manuscripts are to be found here.

Alkali Works, Northwich. *Manchester:* British Dye Stuffs Corporation. *Billingham* near Stockton-on-Tees: Imperial Chemical Industries, Ltd., Synthetic Ammonia and Nitrates, Ltd. This city is the center of the cotton industry; *Bradford* of the woolen industry; *Cardiff* of steel and coal mining; *Newcastle* of the ship building trades. Tin plate works are located at *Mellingriffith*.

France

Paris has long been regarded as the cradle of modern chemistry and the student of chemical history will find much to interest him here. Lavoisier lived at 17 Boulevard de la Madeleine (now rebuilt). Much of his work was done at the Academy of Sciences, founded in 1666. He was executed on the Place de la Concorde and his body lost. An interesting statue of him is behind the Madeleine. The pedestal is adorned with reliefs of him and his wife working in his laboratory, and of him lecturing to a group of his fellow scientists. A collection of his apparatus is preserved at the Conservatoire des Arts et Metiers. This scientific and technological museum contains much historic apparatus, particularly of the great French physicists. Various branches of chemical technology are well represented. A notable feature is the section devoted to the history of photography.[7] A statue of Leblanc, of "soda" fame, stands at the entrance, and nearby, is a statue of Boussingault, the chemist and agriculturalist. The school devoted to teaching the applications of science and art to industry possesses large laboratories, but is scarcely worth a visit. The Academy of Sciences meets on Monday afternoons in the Institut de France on the Quai de Conti. The meetings are public, but cards of admission must be obtained through the secretarial offices.

STATUE OF LAVOISIER BEHIND THE MADELEINE, PARIS

The Collége de France has played a leading rôle in the development of chemistry. The laboratories, still in use, are much the same as in the early 19th century. The work is divided into two classes, the organic portion being presided over by C. Moureu, while the laboratory of mineral chemistry is headed by Matignon and Chaudron. The lecture room is still as it was when Dumas delivered his famous "Leçons sur la Philosophie Chimique." Berthelot[8] worked here for many years, and many of his classical organic preparations are shown on request. A large statue of him and also one of Claude Bernard, the physiologist, stands in front of the façade in the Rue des Écoles. Berthelot and his wife died the same day and their tombs may be seen in the crypt of the Pantheon.

The chief center of chemical instruction[9] is in the University of Paris,

commonly known as the Sorbonne. The great hall should be visited. It contains a statue of Lavoisier, and in the upper vestibule is a picture of him explaining his theories to Berthollet. Separate laboratories house the various branches of chemistry and some of these are at considerable distance from the main building. The division of general chemistry has been headed in turn by Moissan, Le Chatelier, and Job (recently deceased). The balance of St. Claire Deville and casts made from his aluminum, and Moissan's fluorine apparatus, his electric furnace and its products, are on exhibition. The laboratory of mineral chemistry is in charge of G. Urbain. Here is elaborate equipment for all branches of the study of the rare earths. The organic laboratory has an interesting collection of speci-

THE SORBONNE, PARIS

mens. Physical chemistry, under the guidance of J. Perrin, has recently moved to the magnificent new building adjoining the Institut de Radium. The latter, Rue Pierre Curie, in charge of Madame Curie, is rather difficult to visit, but has exceptional equipment for the physical and chemical study of radioactive materials. The Institut de Chimie Appliqué is devoted to practical instruction to fit students for industrial careers. Chemical laboratories will also be found at the École des Mines, École de Pharmacie, and École Municipale de Chimie. Each of these is in charge of well-known French chemists and most of them have interesting chemical history, as many noted chemists have worked and taught in them.

The chemical visitor will naturally be interested in Pasteur and the surroundings in which he worked. At the École Normale Superieure is the

small building, now used as an infirmary, in which he made some of his experiments, while sub-director of this school. The Pasteur Institute[10] on the Rue Dutot is a world-famous center of instruction and research in microbiology, medicine, and biochemistry. In the gate house resides Joseph Meister who, as a child of 7, was the first person to be treated for rabies. Pasteur's tomb is under the entrance stairs of the main building. It is adorned with mosaics illustrative of his main researches, and, though neglected by the guide books, is one of the most beautiful things in Paris. Though open to the public only on certain Saturday afternoons, scientific visitors may see the tomb and library, treatment rooms, and principal laboratories at almost any hour of the day.

A statue of Pelletier and Caventou, the discoverers of quinine, stands at the corner of the Boulevard St. Michel and the Rue Auguste Comte.

PASTEUR'S LABORATORY AT L'ÉCOLE NORMALE, PARIS

A statue of Chevreul is in the Jardin des Plantes, near the Museum. Much scientific history, especially in biology, has transpired at the Jardin and its collections are world famous. In the cemetery of Père-Lachaise are the tombs of Gay-Lussac, Dulong, Wurtz, and also of the Comtesse de Rumford, Lavoisier's widow. Count Rumford is buried in the cemetery at Auteuil. His tomb was damaged during the Commune (1871) and restored at the expense of Harvard University.

The headquarters, library, and assembly hall of the Société Chimique de France are at 44 Rue de Rennes. The Société de Chimie Industrielle has its headquarters at 49 Rue des Mathurins. The office of the secretary of the International Union of Pure and Applied Chemistry (M. Jean Gerard) is also located here. This office can give information about visits to industrial chemical plants. La Maison de la Chimie, designed to be an

International Chemical Headquarters, has already received donations of over $1,000,000. It will be built at the intersection of the Avenue de President Wilson and Avenue de Jena.

From the chemical standpoint the provincial French universities of importance are Lyon (Grignard), Toulouse (Sabatier), Nancy (with a fine new laboratory excellently equipped) and Lille (with admirable facilities largely of post-war origin). The visitor to the south of France (Nice) should not fail to visit the perfume and flower industries at Grasse. The industries are roughly grouped in the following districts: Pas de Calais (Lens) mining; North France (Tourcoing, Roubaix) textiles; Lorraine (Briey, Longwy, Hayance) metallurgy; Pechelbroun, oils; Mulhouse.

"LE GRAND NEPTUNE," VERSAILLES

potassium salts; Lyon, silk factories; Larvy, Grenoble, Dauphiné, olive oil; Paris, chemical, motor, and electrical works.

The American University Union maintains an office at 173 Boulevard St. Germain. Here will be found reception and reading rooms and an organization designed to furnish information to American students or to scientists. The Office National des Universités et Écoles Francaises at 96 Boulevard Raspail may be useful. The Handbook for American Students in France issued by the Institute of International Education contains much information, as does L' Enseignement en France, by Richard, published by Librarian Armand Colin.

Germany

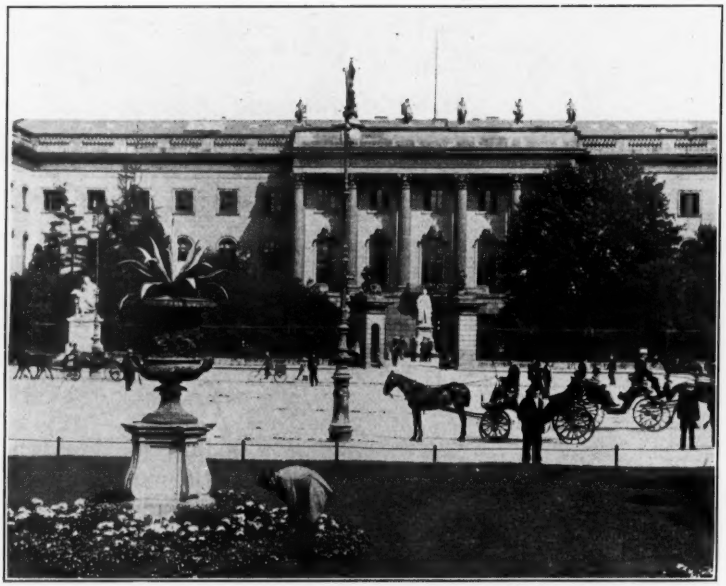
The chemical tourist may well begin his sightseeing of Germany in Berlin. This is essentially a modern city and its chemical attractions are

up-to-date. The center of chemical thought here is the Hofmann Haus, Sigismundstrasse 4, the headquarters of the *Deutsche Chemische Gesellschaft.* The auditorium contains a remarkable collection of portraits of notable German chemists. The library is quite extensive, though second to that in London. This building also houses the editorial offices of the *Berichte, Zentralblatt,* the new Beilstein and the new Gmelin. A large statue of A. W. Hofmann is here. The former chemical laboratory of the university is now occupied by the Museum of Oceanography (Georgen-

THE HOFMANN HOUSE, HEADQUARTERS OF THE *Deutsche Chemische Gesellschaft,* BERLIN

strasse). The present laboratories of organic and general chemistry in the Hessischestrasse were built by Emil Fischer,[11] and much of his work on carbohydrates, proteins, and tannins was done here. The professor's residence in which he lived adjoins the institute. Nearby is a large statue of him, erected by the chemical industries. It faces a statue of Robert Koch. W. Schlenck is the present director of the institute and among those associated with him are F. Paneth[12] and H. Pringsheim, both of whom have been visiting professors at Cornell. Emil Fischer is buried in the ceme-

KAISER WILHELM INSTITUTE OF CHEMISTRY, DAHLEM, BERLIN



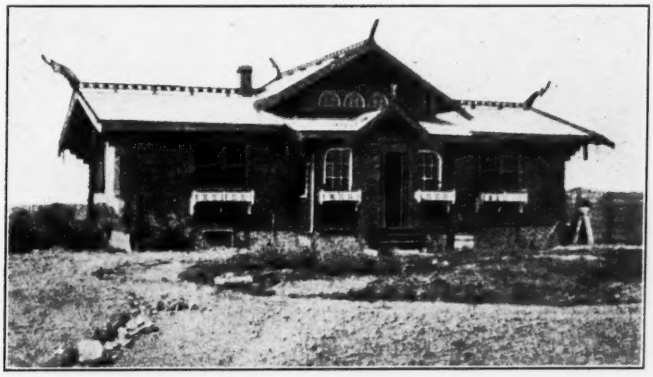
Underwood and Underwood

UNIVERSITY OF BERLIN

These buildings, once the home of a prince, are now frequented by 6500 students.

tery at Wannsee. The laboratories of physical chemistry (Bunsenstrasse), under the direction of M. Bodenstein, are well equipped. W. Nernst, who formerly headed this laboratory, is now director of the Physics Institute, immediately adjoining.

A number of research laboratories known as the Kaiser Wilhelm Institutes, corresponding to our Carnegie and Rockefeller Institutions, are located in the suburb of Dahlem. Each specializes in a particular field, such as biology, experimental therapy, biochemistry, etc. The chemist will be particularly interested in the building devoted to physical chemistry, as this contains the very active laboratories of F. Haber and H. Freundlich. The nearby Institut für Chemie, is devoted to research in radioactivity and in organic and inorganic fields. E. Beckmann was the first director and R. Willstätter did much of his work on anthocyanins here.



VAN'T HOFF'S LABORATORY IN DAHLEM, SUBURB OF BERLIN

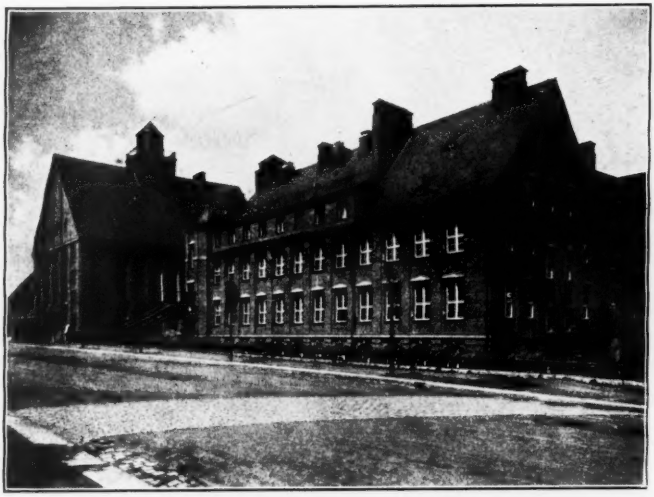
Van't Hoff's last work was done here and Beckmann is buried in the small cemetery here. There are also institutes of metallurgy, leather, silica, etc., here. The Botanical Gardens at Dahlem are quite extensive and interesting. The Robert Koch Institut für Infektionskranheiten is an important center of chemotherapeutical research.

The Prussian State Library (Unter den Linden 38) contains the Darmstaedter collection of scientific manuscripts, probably the largest of its kind. Practically all authorities in all branches of science are represented here, and the chemical section is particularly strong. The specimens which include such treasures as an atomic weight table by Dalton, an electromotive series by Volta, and Lavoisier's notebook, may be examined by qualified visitors.

The German Hochschule are not high schools in the American sense,

but are actually technical universities, corresponding to our better engineering schools. The one at Charlottenburg has large chemical laboratories directed by K. A. Hofmann. The Physikalisch-Technische Reichsanstalt, corresponding to our Bureau of Standards, is also in Charlottenburg. The Chemisch-Technische Reichsanstalt is in Talerweg, Plotzensee. The Material Prüfungsamt at Lichterfelds is remarkable. The Natural History Museum, the Zoölogical Garden, and the Ethnographic Museum are recommended. The Zoo contains a modern Planetarium that no scientific visitor should miss. The Ufa cinema shows scientific films exclusively.

The Technical High School in Dresden has a magnificant new Chemical

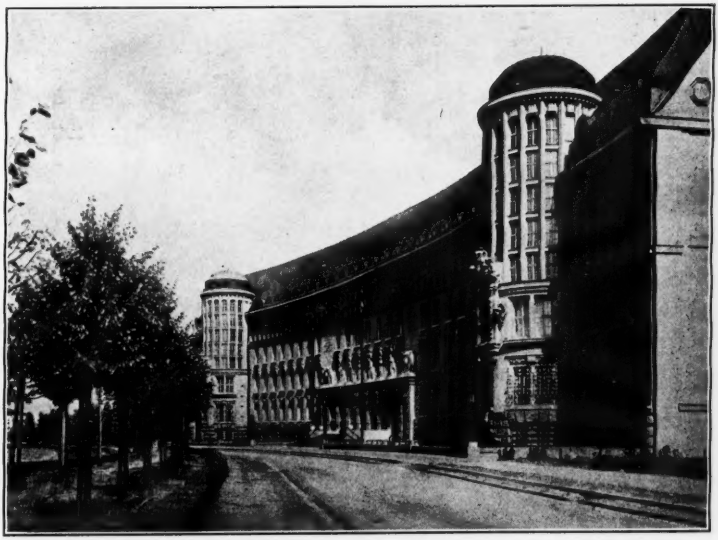


NEW CHEMICAL INSTITUTE OF THE TECHNICAL HIGH SCHOOL IN DRESDEN

Institute. This is the largest German post-war laboratory and it contains many novel features. The various fields have separate laboratories with modern equipment and any one interested in the newest German ideas of laboratory construction will find a wealth of suggestions here. Mementos of Hempel are shown. The best known of the professors here are F. Foerster (inorganic and physical) and A. Lottermoser (colloids). The well-equipped institute for the scientific study of photography is nearby. It is directed by R. Luther of "Ostwald-Luther" fame.

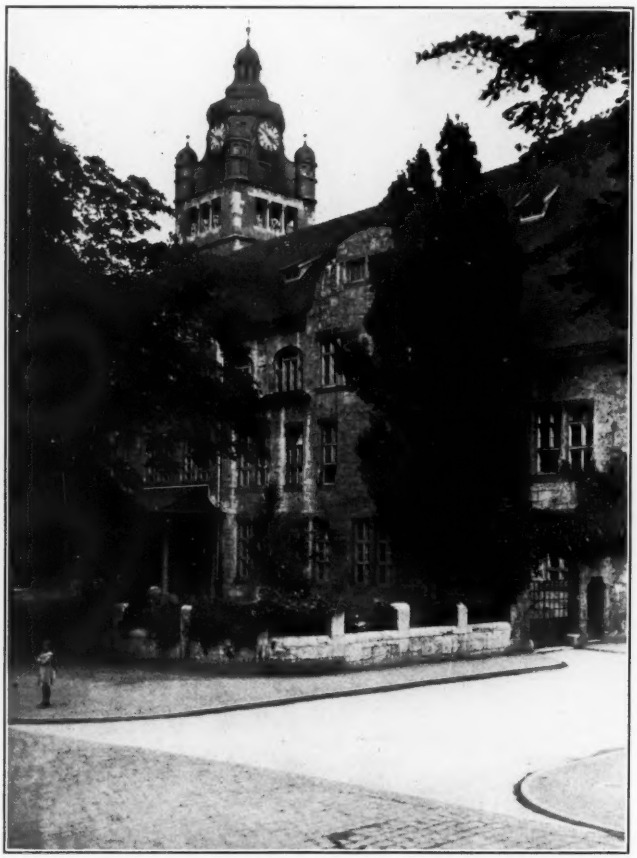
Leipsic has long been famous for chemical education and research. The three chemical laboratories are some distance from the central university building. The main chemical laboratory on Liebigstrasse has been di-

UNIVERSITY OF LEIPSIC
Built originally 1834–1836. Rebuilt 1894–1896.



DEUTSCHE BÜCHEREI, LEIPSIC

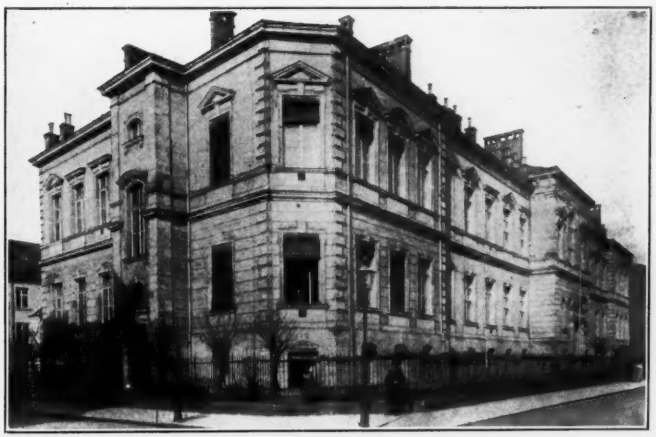
rected in turn by Kolbe, Wislicenus, and Hantzsch (recently retired). The laboratories, though large, are by no means modern, but much chemical history has been made here. The Institute of Practical Chemistry is quite near. This also is rather antiquated. It deserves a visit as it may



THE UNIVERSITY OF JENA

be regarded as the cradle of German physical chemistry, for Wilhelm Ostwald worked here when he was first called to Leipsic. E. Beckmann developed a great deal of his molecular weight apparatus in this building. This laboratory is now under the direction of C. Paal. The Institute of Physical Chemistry, some distance from the other laboratories, was built

by Ostwald, and many eminent chemists, including numerous Americans, have studied here. The laboratory has suffered from lack of funds and the equipment is not adequate for modern work. The present director is Max Le Blanc (electro-chemistry) and associated with him are C. Drucker (general physical), W. Böttger (analytical), Wo. Ostwald (colloids), and F. Weigert (photo-chemistry). Leipsic is famous for its publishing houses and book dealers, many of them carrying large stocks of chemical periodicals. The Deutsche Bücherei, in which is deposited every German book printed since 1913, is well worth a visit.



CHEMICAL LABORATORY, UNIVERSITY OF ERLANGEN
This laboratory was opened in 1901.

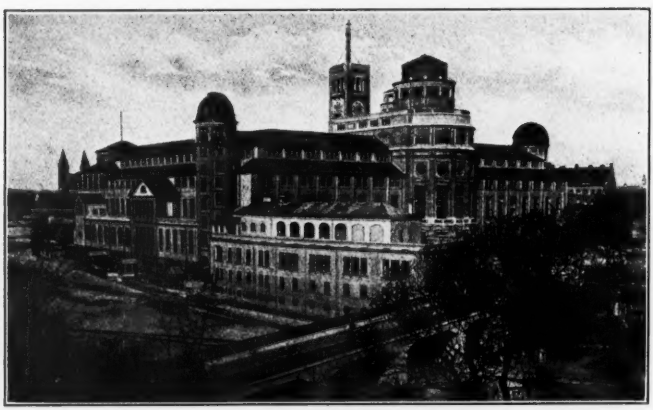
The Chemical Institute of the University of Jena contains nothing of unusual interest, but the chemical visitor will be well repaid by a visit to the glass works of Schott and Genossen, the makers of "Jena" glass. It is well to apply in advance for admission. The optical works of Zeiss, near the Chemical Institute, are usually not open to visitors. The house in which G. E. Stahl, the phlogistonist, lived is marked with a placard.

Erlangen is an excellent example of the smaller German university. It is the alma mater of Liebig, and the house in which he lived as a student is marked by a tablet. The main chemical laboratory, directed for many years by Otto Fischer, is far from modern. It is now directed by R. Pummerer (organic) and associated with him is F. Henrich ("Theories of Organic Chemistry"). The new Institute of Applied Chemistry is well planned and thoroughly modern. It is directed by M. Busch of nitron fame.

The Germanisches Museum at Nuremberg contains an interesting collection of alchemical and old pharmaceutical apparatus.

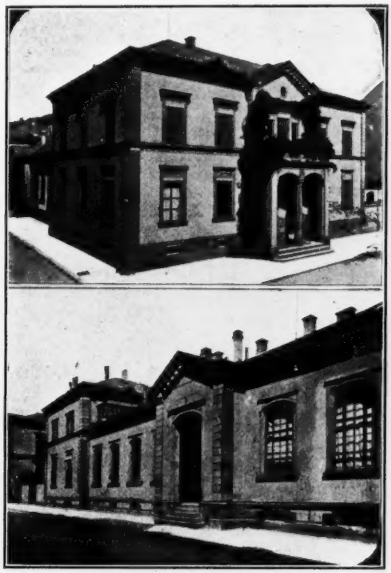
The Chemical Institute of the University of Munich has been directed by Liebig, Baeyer, Willstätter, and now by H. Wieland. The laboratory has been extended, and is a strange combination of old and new construc-

THE UNIVERSITY OF MUNICH FROM LUDWIGSTRASSE



DEUTSCHES MUSEUM, MUNICH

tion. The atomic weight laboratory, presided over by O. Hönigschmidt, is notable. Others teaching here include K. Fajans (physical), W. Prandtl (rare earths), and L. Vanino (luminescence). A rather ludicrous statue of Baeyer has been erected at the side of the laboratory. Baeyer's work on indigo and benzene and Willstätter's study of the enzymes were carried

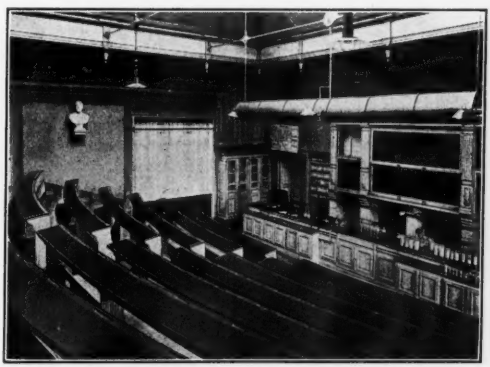


TWO VIEWS OF BUNSEN'S LABORATORY AT HEIDELBERG—UPPER VIEW, LIVING QUARTERS; LOWER VIEW, HIS LABORATORY, AN EXTENSION OF THE HOUSE

VIEW OF BUNSEN'S OFFICE

out here. The latter now works in his own private laboratory. An excellent statue of Liebig adorns the Maximilian Platz. His grave, in the old South Cemetery, is marked with an unostentatious stone, surmounted by a marble bust enclosed in glass. In the arcades of this cemetery is the grave of Fraunhofer. Baeyer is buried in the Waldfriedhof.

The Technical High School has excellent chemical facilities and W. Manchot and Hans Fischer direct the divisions of inorganic and organic, respectively. Americans will be interested in the English gardens and large park laid out by Count Rumford, whose statue stands near the National Museum. The zoölogic and



LECTURE ROOM OF BUNSEN AS IT IS TODAY

mineralogic collections in the Academy of Science buildings are very good.

The Deutsches Museum is the most wonderful technical museum in the world. It contains the largest and best collections of scientific and technical material. All branches of science and technology are represented,

STREET SHOWING LIEBIG'S BIRTHPLACE AT DARMSTADT

and though not completed, it has nine miles of exhibits. Not less than a week is necessary to gain an adequate idea of its contents and a thorough study would consume at least a month. A wealth of historic apparatus is shown; likewise, faithful reproductions of classic experiments. Working models that may be operated by the visitor are used wherever pos-

sible. Not less than a day should be spent in the chemical section. The arrangement follows the historical order, beginning with the primitive peoples, alchemy, the development of modern chemistry, both pure and applied, and is brought up to date by the exhibition of the isotopes of lead. As the official guide devotes 20 pages of fine print to a cursory description of the chemical section alone, the importance of this collection cannot be exaggerated.

The Technical High School at Karlsruhe has rather old but adequate laboratories. Of those now teaching there G. Bredig (physical) and S. Goldschmidt (organic) are best known. Haber investigated the ammonia equilibrium in this laboratory, and his original apparatus is shown. The

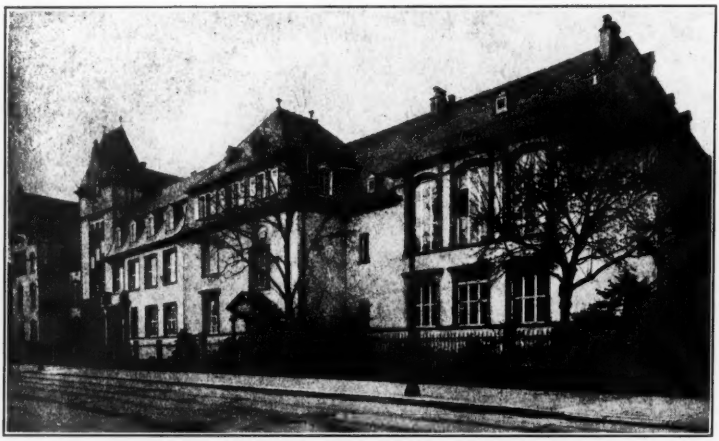
KEKULÉ ROOM IN THE TECHNICAL HIGH SCHOOL, DARMSTADT

physics laboratory contains a collection of apparatus used by Hertz in his work on the electro-magnetic waves, one of the important steps in the development of wireless and radio. A statue of him stands in the courtyard.

Leopold Gmelin, Bunsen, Victor Meyer, and Curtius have upheld the greatness of Heidelberg as a scene of fruitful chemical activity.[13] The laboratory built by Bunsen[14] has been extensively remodeled and enlarged, but its facilities do not compare with more modern laboratories. K. Freudenberg[14] (tannins) is the present director. The former professor's residence adjoining the laboratory has been fitted up recently for physical chemistry. An imposing statue of Bunsen adorns the Leopoldstrasse. At Hauptstrasse 52 a tablet marks the house in which Bunsen and Kirchhoff

made their spectroscopic studies of sunlight. In the cemetery are the graves of Gmelin, Bunsen, Victor Meyer, and Curtius.

Darmstadt has the distinction of being the birthplace of Liebig and Kekulé. The house on the Kaplaneigasse in which Liebig was born (1803) has just been rebuilt and refurnished as of that date. It contains a collection of Liebig relics. It is planned to build a museum adjoining to house materials relating to the industries closely associated with Liebig, *i. e.*, agriculture, nutrition, pharmacy, etc. Mementos of other eminent Hessian chemists will also be preserved here. The birthplace of Kekulé (1829) at the corner of Hügel and Neckarstrasse stands unchanged. The Technical High School contains a room devoted to Kekulé souvenirs.



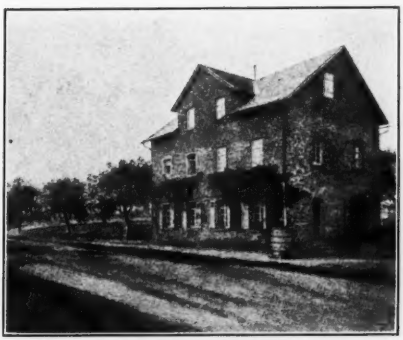
GEORG-SPEYER-HAUS, FRANKFURT-AM-MAIN, STATE INSTITUTE FOR EXPERIMENTAL THERAPY AND CHEMOTHERAPY INVESTIGATIONS

Its chief treasure is his notebook containing Liebig's lectures which he heard at Giessen. The original benzene model is also on exhibition. E. Berl is perhaps the best known of the professors at Darmstadt.

Frankfurt-am-Main has new chemical laboratories. J. von Braun (organic) and F. Hahn (analytical) are teaching there. The well-equipped Institute of Physical Chemistry is directed by R. Lorenz. The Institute of Experimental Therapeutics, known locally as the Speyer Haus, is headed by W. Koble. It is famous as the scene of Ehrlich's work on salvarsan. The Institute of Colloidal Research at the Medical School is headed by H. Bechhold.

Wöhler was born (1800) at the little town of Eschersheim, 6 miles from Frankfurt, in a modest parsonage, now marked with a tablet.

Giessen might be regarded as the Mecca of the organic chemists, or of chemical teachers in general, for it was here that Liebig established (1824) the first chemical laboratory devoted entirely to instruction.[15] The laboratory has fortunately been saved from destruction and has again been fitted up as it was in his time, either with originals, or excellent reproductions. This museum gives the present-day chemist a truthful idea of the handicaps confronting the pioneer workers, and illustrates definitely the axiom that a gilded cage is not necessary for golden song. The rooms above the laboratory were occupied for many years by Liebig and his family. An excellent statue of him is near the Botanical Gardens. On the outskirts of the town is the Liebig Höhe, a plot of ground where he made practical tests of his artificial manures. The house in which A. W. Hofmann was born is marked with a tablet. The present Chemical Institute of the University is in charge of K. Elbs.



LIEBIG HÖHE IN GIESSEN

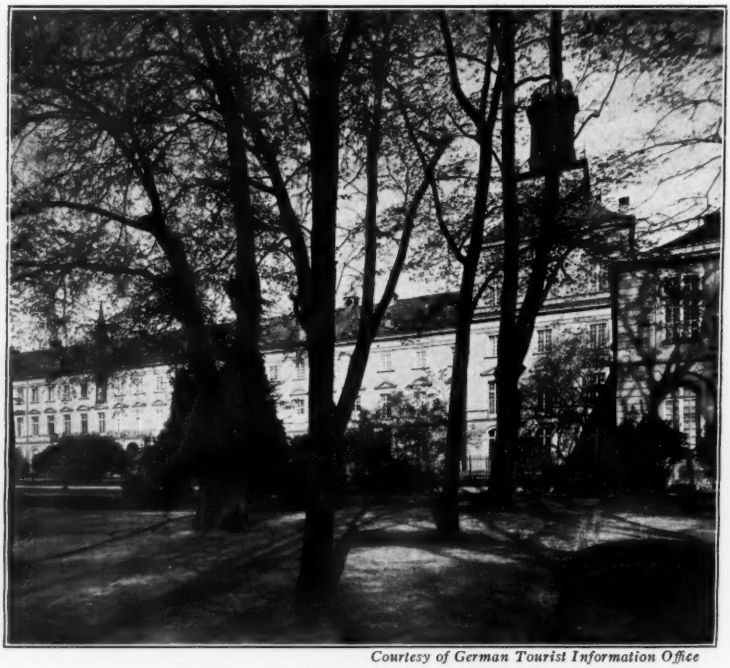
Göttingen, to the chemist, is indelibly associated with Wöhler who worked here from 1836 until his death in 1882. His laboratory and house on the Hospitalstrasse, his monument on the Nicolaistrasse, and his grave are all worthy of a visit. Otto Wallach was professor here for many years. The high standard of chemistry at Göttingen today is evidenced by the presence there of A. Windaus, R. Zsigmondy, and G. Tammann.

The Chemical Institute at Bonn was built under the direction of A. W. Hofmann, but its first director was Kekulé,[16] who taught here from 1767 to his death in 1896. His living quarters over the laboratory and the imposing monument at its entrance are objects of interest. He is buried in the Poppelsdorfer Cemetery about a mile from the laboratory. The present director is P. Pfeiffer. In the old cemetery at Bonn is the grave of F. Mohr,[17] the father of volumetric analysis. The Neanderthal skull is exhibited in the Provincial Museum.

The University of Rostock in the far north is well known in chemical literature because of the activity of the director of its Chemical Institute, Paul Walden. At Wiesbaden is the famous Fresenius laboratory, of great importance in the history of analytical chemistry. E. Abderhalden's laboratory at Halle is of interest to biochemists. The Kaiser Wilhelm Institut für Kohlenforschung is at Mülheim-Ruhr. The mining schools at

Bochum, Westphalia, and at Freiberg, Saxony, are world famous and possess extensive museum collections. The experimental laboratory of the Bergius process is at Rheinau. The Porcelain Works at Berlin and at Meissen are well known, likewise the works at Nymphenburg-Munich.

The above has by no means exhausted the schools and laboratories in which items of interest to the chemist may be found, but enough has been given to indicate the wealth of "sights" awaiting the chemical visitor to Germany. The universities are closed during August and September.



Courtesy of German Tourist Information Office

THE UNIVERSITY OF BONN (THE BEETHOVEN CITY)

The following addresses may be useful to those seeking information regarding German schools: Amerika Institut—Universitätstrasse 8, Berlin; Akademisches Auskunftamt an der University Berlin; Akademisches Auslandstelle, Kaitzerstrasse 2, Dresden. Remme's "Die Hochschulen Deutschlands," issued by the Akademischer Auskunftamt, will be found useful.

A complete discussion of the German chemical industry would require far more space than is available here. Furthermore, each division should

be written by a specialist for specialists. There are, however, certain industries in which most chemists are interested and the list below has been chosen from this standpoint. Most of this information was taken from the itineraries followed by Professor B. Rassow of Leipsic who makes an annual inspection tour with his students in technical chemistry.

Rhine-Ruhr District.—I. G. Farben Industrie A. G., *Leverkusen;* Silicawerk Heinrich Koppers A. G., *Duisberg-Heerdt;* Gessellschaft für Teerverwertung, *Duisberg-Meidreich;* Fried. Krupp A. G., *Essen;* Friedrich-Alfred—Hütte der Fried. Krupp A. G., *Rheinhausen;* Mineralölwerke A. G., *Rhenania—Ossag, Monheim;* Zündhölzerfabrik Joh. Salm, *Hitdorf.*

Middle Rhine District.—Joseph Vogele A. G., *Mannheim* (enameled apparatus for chemical industries); Deutschen Steinzeugwarenfabrik, *Friedrichsfeld;* Badische Anilin und Soda Fabrik, *Ludwigshafen;* Pfaudler Werke A. G., *Schwetzingen* (glazed steel containers); Chemischen Fabrik F. Raschig, *Mannheim* (tar distillation); Spriegelmanufaktur Waldhof A. G., *Mannheim.*

Bavaria.—Holzverkolungs Industrie A. G., *Schweinfurt* (acetic acid, urania green); Gademan & Co., *Schweinfurt* (lithopone); Bayerisches Spiegelglassfabriken, *Fürth;* Tucherbrauerei, *Nuremberg;* Hofseifenfabrik Ribot, *Schwabach;* Löwenbraü Brewery, *Munich;* Alexander Wacker Werke, *Burghausen* (carbide, acetic acid, and electrolytic products).

Information concerning the industries in the Berlin district or any other district may be obtained from the Vereins zur Wahrung der Chemischen Interessen Deutschlands, Sigismundstrasse 3, Berlin. The Kahlbaum factory at Adlershof, Berlin, is of interest to all organic chemists and it may be seen by special application. The tremendous installation at Merseburg near Leipsic, known as the Leunawerke, covers an area of 9 sq. kilometers. The Haber process is in active use here and 1500 tons of atmospheric nitrogen are fixed each day. The Schimmel Works at Militz-Leipsic are known for their production of essential oils.

Switzerland

From a chemical standpoint, the best known of the Swiss schools are those in Zürich. The University of Zürich has excellent laboratories. Alfred Werner[18] did much of his work there and an interesting collection of his preparations may be seen. V. Henri has charge of physical and P. Karrer of organic. The Federal Technical High School, also at Zürich, has special interest for American chemists because Treadwell taught there for so long. He was perhaps the unique example of an American holding a professorship in a European institution of higher learning. His son, W. D. Treadwell, is now director of the analytical division. Many eminent chemists have taught in this school. One of these was G. Lunge, the authority on heavy chemicals. H. E. Fierz has charge of the work in industrial organic, E. Baur of physical, and R. Kuhn of organic and in-

organic. P. Debye and R. Scherrer are teaching at the Physical Institute of the University.

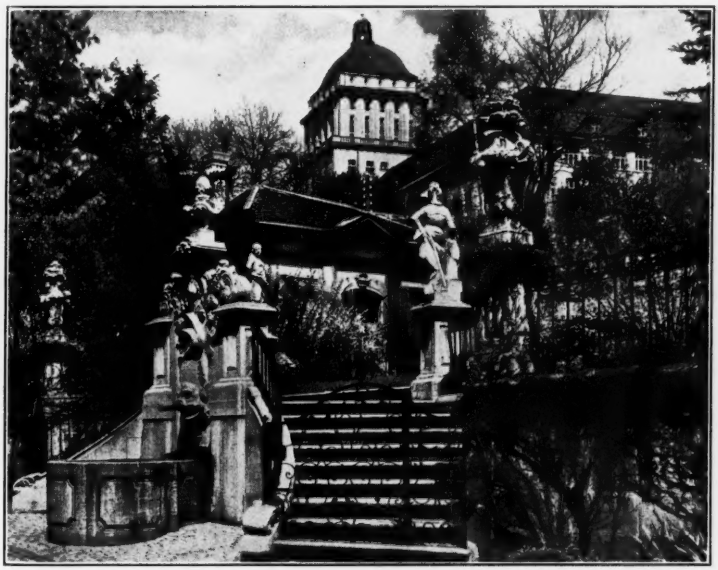
The University of Basel was the scene of Schönbein's activities and mementos of him are exhibited in the very excellent museum there. The laboratories housing organic (H. Rupe) and inorganic (F. Fichter) are rather old, but physical chemistry (A. L. Bernoulli) has wonderful new laboratories equipped with all the latest facilities. Adjoining this is

THE POLYTECHNIC, ZÜRICH

the physics laboratory, exceptionally well equipped and having a good museum. The laboratories at Berne are adequate, though not new. Teaching there are V. Kohlschütter, F. Ephraim, and J. Tambor. The outstanding chemist at Geneva is Amé Pictet, whose recent work on sugars has attracted so much attention. His lectures in general chemistry are said to be particularly well illustrated by demonstrations. Humphry Davy died and was buried in Geneva.

Information concerning the Swiss schools may be obtained from: Bureau

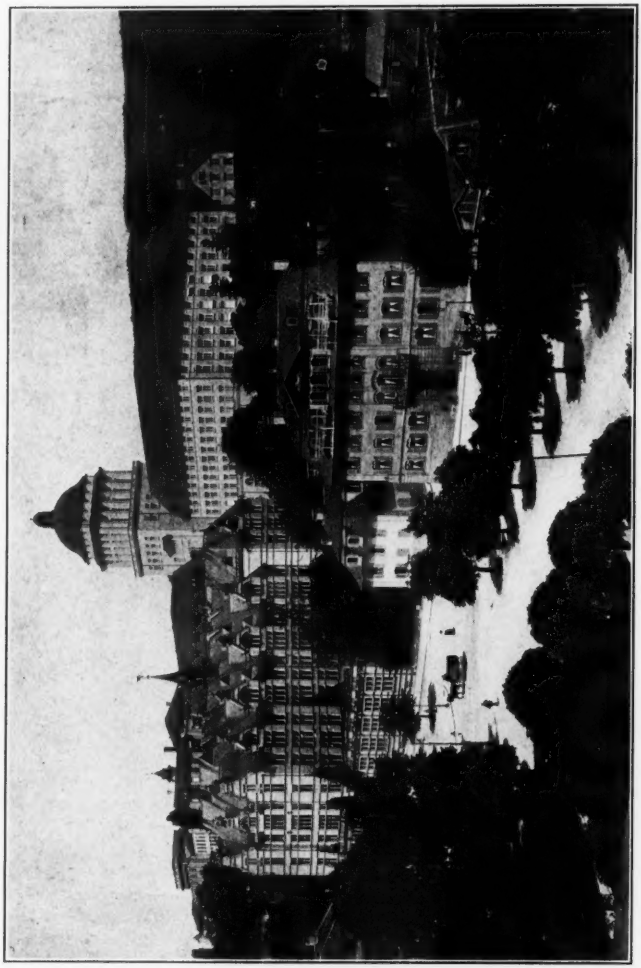
The University of Geneva



Entrance to the University of Zürich

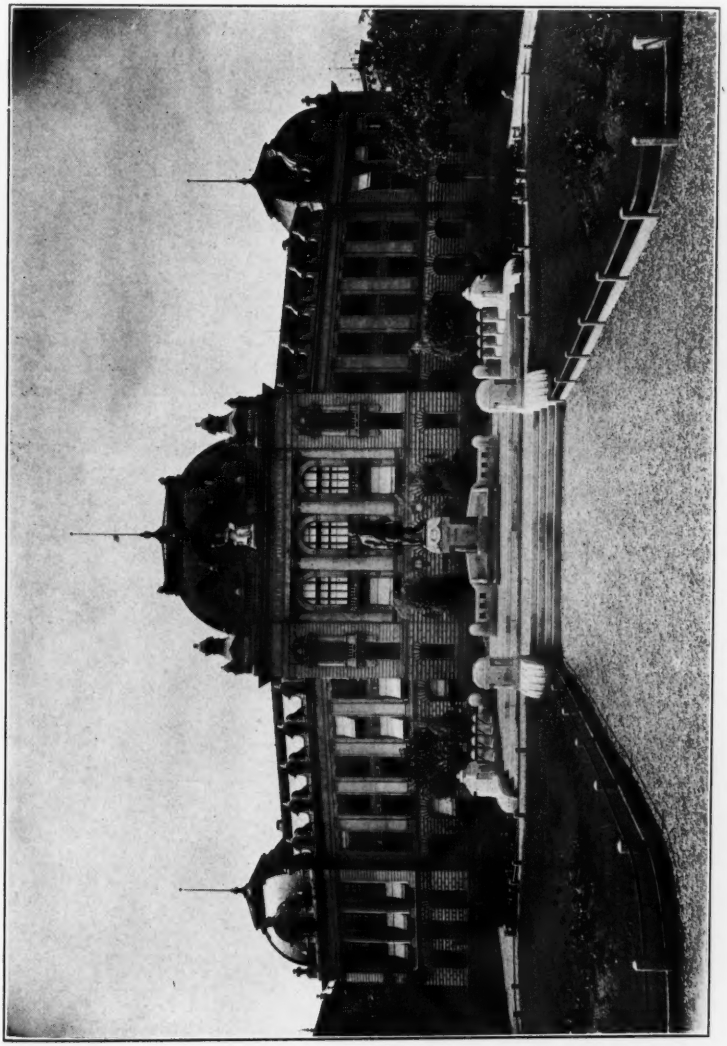
International d' Education, 4 Rue Charles Bonnet, Geneva; Office Central Universitaire, Zeitglockenlaube, Berne.

The chemical industries of Switzerland are mainly concerned with the



THE UNIVERSITY OF ZÜRICH

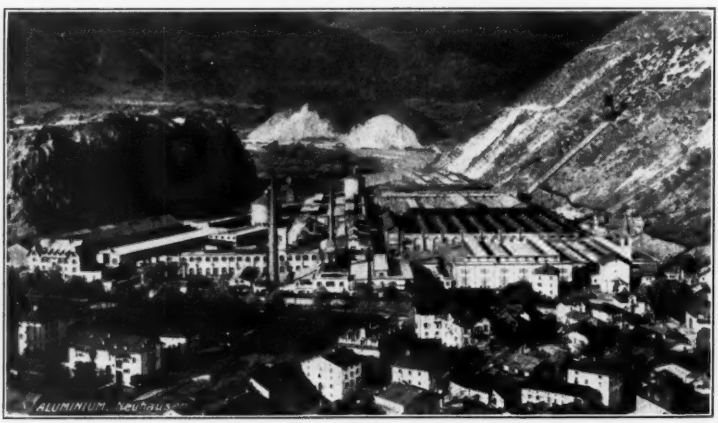
production of dyes and pharmaceuticals; electro-chemical products, especially aluminum; artificial silk. The manufacture of the first is centered at Basel and some of the more important plants there are: Gesellchaft



THE UNIVERSITY OF BERNE

THE UNIVERSITY OF LAUSANNE
Market-day on the Place de la Riponne at Lausanne-Ouchy, on the Lake of Geneva.

für Chemische Industrie; Chemische Fabrik vorm. Sandoz; F. Hoffmann and La Roche; Chem. Fabrik Durand and Huguenin. Elektrisitätswerk and Chem. Fabrik Courza (Basel) produces calcium carbide and its derivatives. Chem. Fabrik Ustikon, Lake of Zürich, manufactures heavy chemicals. Société usine de la Viscose, Lucerne, makes artificial silk. Aluminum Industrie A. G. Neuhausen produces aluminum.



BIG ALUMINUM WORKS AT CHIPPIS (VALAIS), SOUTHERN SWITZERLAND

Italy

Some of the foundation stones of our modern chemical theory are of Italian origin. Avogadro was professor of physics at Turin and his interpreter, Cannizzaro,[19] taught at Palermo and Rome. Ciamician was professor at Bologna for 32 years and died there. The best known of the living Italian chemists is E. Paterno at Rome. Others whose work is familiar to American chemists are G. Bruni at Milan; L. Rolla at Florence; O. Scarpa at the Royal Engineering School at Turin; and U. Pomilio at Naples. There are three Chemical Institutes at Milan.

MONUMENT TO AVOGADRO AT TURIN

MONUMENT TO CANNIZZARO AT PALERMO

Professor N. Parravano has kindly furnished the following summary of chemical plants in Italy:

Piedmont.—*Chatillon* (*Aosta*), *Veneria Reale* (*Turin*) artificial silk; *Cogne*—iron ore mines; *Turin*—Fiat Motor Car Company.

Liguria.—*Cengio*—dye stuffs and colors; *Vado*—coke and ammonia.

Lombardy.—*Brescia*—Società Stereol, hydrogenation of oils; *Caffaro*—electrochemical works; *Crespi sull'Adda*—textile industries; *Cesano Moderno*—colors.

Three Venetias.—*Murano* (*Venice*) glass; *Merano* (*Bolzano*) synthetic ammonia; *Mori*—aluminum; *Fiume* (*Mestre*) cracking of oil.

Emilia.—*Salsomaggiore* (*Parma*) medicinal waters; *Velleia e Vallenza* (*Piacenza*) petrol; *Pontelagoscuro*—sugar.

Tuscany.—*Larderello*—native boric acid; *Rosignano* (*Livorno*) Solvay soda; *Piombino*—steel works; *Orbetello*—phosphate fertilizers; *Doccia Ginori*—china ware; *Monte Amiata*—cinnabar mines; *S. Giovanni Valdarno*—lignite mines and distillation; *Torre del Lago*—lignite mines and distillation; *Isola d'Elba*—blast furnaces.

Umbria.—*Terni*—hydro-electric plants; *Vera Montoro*—synthetic ammonia; *Fabriano*—paper factory.

Latium.—*Rome*—gas works; *Tivoli*—medicinal waters; *Segni* (*Frosinone*)—cement.

Southern Italy.—*Bussi* (*Aquila*)—synthetic ammonia; *Sessa Aurunca*—leucite; *Cotrone*—zinc; *Bari*—vegetable oils.

Sicily.—*Palermo*—citric acid; *Augusta*—salt; *Campofranco* (*Girgenti*)—sulfur; *Ragusa* (*Catania*)—asphalt.

Sardinia.—*Inglesiente*—galena and blende mines; *Monteponi*—electrolytic zinc.

Information regarding the schools of Italy can be obtained from the Library for American Studies in Italy, Corso Umberto 1, Rome; while inquiries regarding the chemical industries may be addressed to Conseil des Recherches, Rome.

Poland

Although the national life of Poland has undergone many vicissitudes, its chemical history records a steady progress, not surprising in view of the mineral wealth of the country.[20] Alchemy flourished here, and of the Polish adepts Michael Sendivogius (1556–1646) won an international reputation. A chair of chemistry was created at Cracow as early as 1782, and at Vilna in 1784. Kitajewski organized a teaching laboratory at Warsaw about 1825. The Russians closed the universities in 1831 and many of the Polish scientists emigrated and their work in the laboratories of other countries was of the first rank. When the restrictions were removed, a chemical renaissance followed.

The best known masterpiece of Polish research is the work of Olzewski and Wroblewski on the liquefaction of gases, which culminated in the production of liquid hydrogen and argon. It should not be forgotten that Marie Curie, neé Sklodowska, is a native of Poland, though all of her work was done in Paris. She is now engaged in establishing a Radium Institute in Warsaw.

Poland has five universities, Cracow, Lwow, Poznan, Vilna, and Warsaw. Each of these has chairs of organic, mineral, and of physical chemistry, and, in some cases, of chemical technology. The medical schools have biological and pharmaceutical chemistry. Polytechnic schools are situated at Warsaw and Lwow, an Institute of Chemical Research is at Warsaw. It was founded by Ignace Mościcki, the chemist, who is now President of the Polish Republic. Its efforts are largely directed toward improvements in the mineral and organic industries. The Chemical Society of Poland

publishes *Les Annales de la Chimie.* The Society headquarters are at the Polytechnic School, Polna Street 3, Warsaw.

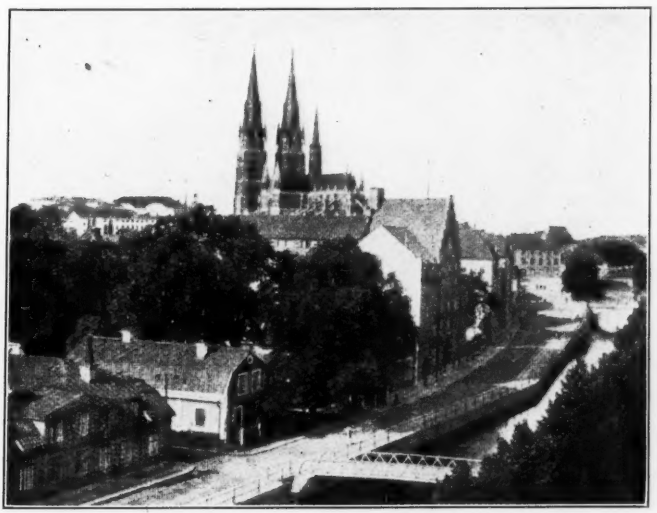
Professor W. Swietoslawski of the Polytechnic at Warsaw has suggested the following as being of possible interest to chemical tourists:

Boryslaw.—Oil wells.
Polmin-Drohobycz.—Petroleum refineries.
Lodz.—Textiles (cotton).
Tomaszow.—Artificial silk.
Wieliczka.—Salt mines.
Kalusz-Stebnick.—Potassium salt mines and concentrating plant.
Upper Silesia.—Coal mines, coke and gas plants, coal tar distilleries, dyes, iron and steel plants, zinc and lead mines and refineries.

The Union of Polish Chemical Industries, Warsaw, Czackiego St. 14, will furnish information relative to visits to industrial establishments.

Sweden

Sweden has two complete universities, and several technical high schools. The best known of the chemists at the University of Lund is Widmark. The university at Uppsala is widely known through the work of The Svedberg. The most novel feature of his colloid laboratory is the ultra-



VIEW OF THE UNIVERSITY TOWN OF UPPSALA

centrifuge which permits the determination of the molecular weights of colloids, particularly proteins. The entrance to the new university laboratories is adorned with busts of Bergmann, Berzelius, and Scheele. The

nearby physics building contains the laboratory of Manne Siegbahn. Much of the work of Olaf Hammarsten, the physiological chemist, was done in the neighboring old chemical laboratory. Uppsala was the alma mater of Arrhenius, and he is buried in the cemetery there, as are Jonas and Knut Ångstrom. In the great market square, in the house still occupied by a druggist, was the chemist's shop "Upplands Vapen" in which

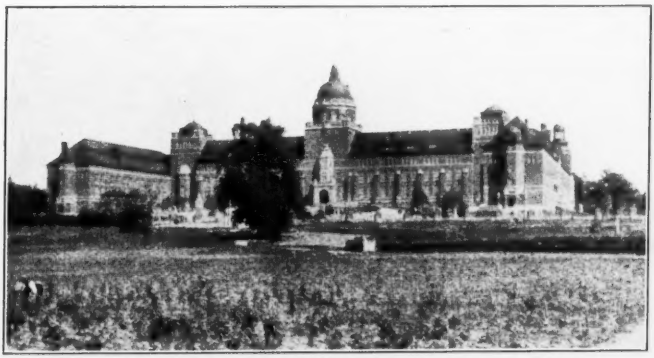
Underwood and Underwood

THE UNIVERSITY BUILDING FROM THE CATHEDRAL STEEPLE AT UPPSALA

Scheele lived and worked. A tablet states that Carl Wilhelm Scheele lived in this house, 1770–1775, and "here discovered oxygen and other elements of nature." It was here that he met and worked with Tobern Bergmann and the mineralogist J. G. Gahn. The library of the University contains the Stockholm Papyrus.[21]

Anders Celsius, the inventor of the Centigrade thermometer (1742), was

professor here for many years. A tablet marks the house in which he had his observatory. Emanuel Swedenborg (died 1772), who has sometimes been called "the da Vinci of the North," is buried in the cathedral. Besides founding the religious system for which he is most generally known,

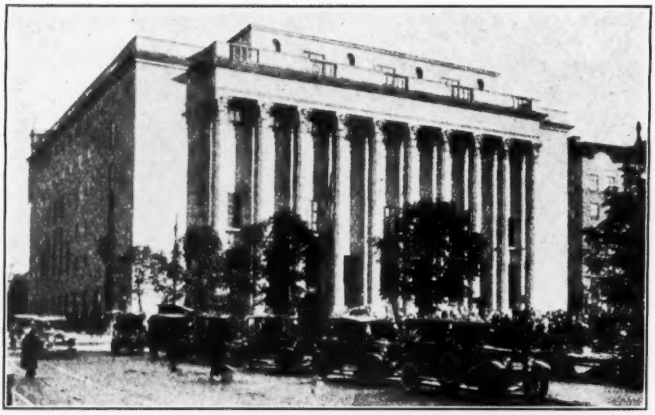


NATURAL HISTORY MUSEUM OF SWEDEN
This museum contains large and valuable collections and forms part of the "City of Science" near Stockholm.

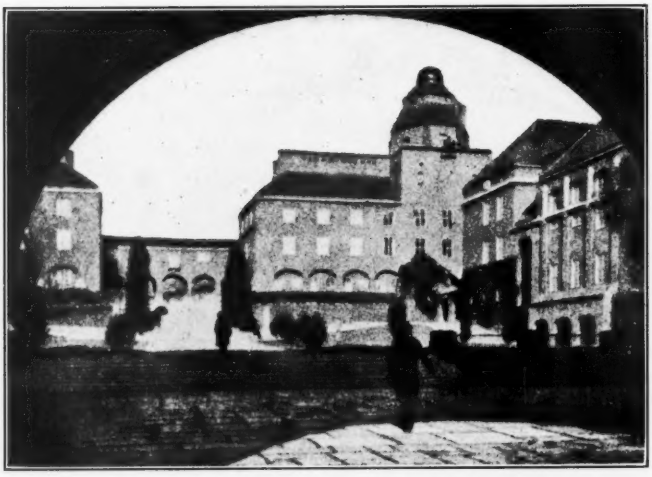
ROYAL COLLEGE OF TECHNOLOGY, STOCKHOLM
Technical education in Sweden ranks very high, and the country possesses a great number of highly efficient engineers.

he was also an engineer, scientist, builder, and musician. He wrote a chemistry text which embodied an original system of nomenclature. Uppsala's most famous son was Carl von Linné. His garden is kept up and the museum in it contains mementos of him. He is buried in the cathedral.

In the Berzelius Park in Stockholm is a statue of that great chemist and in Humlégarden, a park near the Royal Library, are statues of Scheele



THE CONSERT HALL OF STOCKHOLM
The Nobel Prizes are awarded in this hall.



THE POLYTECHNICAL HIGH SCHOOL AT STOCKHOLM

and Linné. Berzelius lived in the Königinstrasse in the upper story of the Academy of Science. His laboratory lay to the south of the great Torweg and the rooms now are part of the residence of the secretary of

the Academy. The Natural History Collections at the Academy are particularly good. The University "Högskola" and the Royal College of Technology have excellent chemical facilities. The Biochemical Institute, aided by the Rockefeller Foundation, and forming a part of the Medical School, is directed by Euler, a Swiss chemist, an authority on enzyme action. Every scientist is interested in the Nobel Foundation which administers the fund of approximately $7,000,000 left by Alfred Nobel, the inventor of dynamite. The income is divided into five yearly prizes, one each in chemistry, physics, literature, medicine, and advancement of peace. The prizes are awarded at very impressive ceremonies conducted at the Consert Hall.[22] The Nobel Institute of Physical Chemistry is also located in Stockholm.

Swedish iron has long enjoyed an enviable reputation. Ekilstuna has been called the Sheffield of Sweden. Impressive iron mills are also located at Bofors, Motala, and Domnarvet. The S. K. F. ball-bearing works are at Göteborg. The match industries are at Jönköping where all the establishments have been amalgamated into the Svenska Tandsticks Aktiebolaget (Swedish Match Company). The wood pulp and paper industry is of great importance. Typical plants may be visited at Skoghall, Wargön, Norrköping, and Skutskär. Electrometallurgy may be seen at Lilla Edet, Trollhättan. Iron mines are at Grängesberg, and a copper mine at Falun. Information relative to the Swedish chemical industries may be obtained from Sveriges Kemiska Industrikontor, Stockholm.

The chemical visitor to Norway will be most interested in the nitrogen fixation plants at Notodden. The power plant at Rjukan develops 300,000 H.P. At Borregaard are wood pulp, paper, and large metallurgical works. There is a university at Oslo (Kristiania).

Denmark

The laboratories of the various institutions at Copenhagen are at present extremely fruitful. The Carlsberg laboratory has been heavily endowed and at present is the outstanding laboratory in northern Europe for the investigation of biologic problems. For many years it was directed by Kjeldahl and a fine portrait of him may be seen there. The present director is S. P. Sørensen. He has over 30 students working under him, chiefly on the fractionation of proteins. Work on the proteolytic enzymes is also in progress. K. Linderstrom-Lang is also working there.

J. W. Brønsted has his laboratory at the Polytechnical School and Nils Bjerrum at the Royal Agricultural College. They have international reputations as physical chemists, and much of their recent work has been in substantiation of the Debye-Hückel theory. The physicist, Nils Bohr, works at the Institute named for him. E. Biilman is professor of chemistry at the University.

Holland

Holland has always produced scientific leaders and a study of the Nobel Prize lists will show that this virile people has not retrograded in this respect. The chemical tourist may expect to find much of interest in this small country. The university laboratories contain apparatus used by those who helped to build modern chemistry, and portraits of these distinguished scientists adorn the walls of the university senate chambers.

The laboratory at Amsterdam was built by van't Hoff. He worked here for many years, as did Roozeboom, Holleman, and van der Waals. Though not a chemical industry, the Ascher Diamond Works are of great interest.

THE LABORATORY BUILT BY VAN'T HOFF AT AMSTERDAM

The city possesses modern gas, light and water works, likewise modern breweries.

The University of Leyden has had a distinguished career and it has been said that the auditorium with its portraits of distinguished professors is one of the most memorable places in the history of science. Boerhaave[23] taught here and made the medical school renowned. The library is rich in manuscripts and the chemist is particularly interested in the Leyden Papyrus,[24] probably the oldest chemical treatise in existence. The Cryogenic Laboratory in which Kammerlingh Onnes carried out his famous researches on the liquefaction of gases is still in use.

Utrecht was the alma mater of van't Hoff, and the laboratory there bears his name. Ernst Cohen and H. R. Kruyt are working there at present. There is a university also at Groningen. At Delft is a technical school[25] and a great rubber institute.

The Philips Works (electric light bulbs, radio, etc.) at Eindhoven maintains one of the world's largest private research laboratories. At Weesp and Bussum, interesting chocolate works may be seen. The margarine industry is well developed in Holland and typical factories are van der Bergh at Rotterdam and Jurgens at Dordrecht. Those interested in engineering should see the Zuidersee Works at Wieringen and the North Sea Canal Locks at Yminden. The cheese factory at Edam is well worthwhile.

Belgium

The Belgian universities are at Ghent, Brussels, Louvain, and Liége. The laboratories at Liége have suffered from war and flood and offer little incentive to a chemical visitor. Much of Spring's work was done here.

NEW LABORATORY OF THE POLYTECHNIC SCHOOL, BRUSSELS
This laboratory houses biology and physics in addition to chemistry.

The building at Louvain is fairly new though the poverty of the Belgians prevented the inclusion of anything but the necessities in the equipment. The school at Brussels has old laboratories, still heated by stoves, a striking contrast to the new laboratories of the Polytechnic School[26] (the engineering branch of the University), which are thoroughly modern and well equipped. The arrangement is said to have suffered because of insistence on a standardized plan for all the science laboratories. The Solvay Institute in Brussels is devoted to biochemistry. Here are preserved the balances, weights, and library of J. S. Stas. The Academy of Science has beautiful rooms in a building near the Royal Palace. The assembly hall is particularly striking.

The laboratories of the University of Ghent offer little that is different. They are in charge of F. Swarts, who has specialized on fluorine organic

compounds. Ghent is famous in chemical history as being the birthplace of the benzene ring theory. Kekulé was professor here (1858–67) and it was here that he had the well-storied vision of the snake seizing its tail.

Prof. Leon Crismer, Military School, Brussels, is the secretary of the Chemical Section of the National Belgian Research Committee, and inquiries relative to Belgian chemical industries may be obtained from his office.

Czechoslovakia

The picturesque city of Prague is famous in chemical history because it was here that Rudolph II (1553–1612) gathered a company of alchemists and himself worked with them in their efforts to transmute basic metals into gold. Some of these work places have been preserved in the Gold Street.[27] As the city is bilingual there is a German university here, founded 1383, in addition to the newer Czech and Ukrainian schools. There are also universities at Bratislava and Brno (Brünn). In the latter city is the monastery in whose garden Mendel raised his peas. Tycho Brahe worked for a short time at Prague and is buried there. He was succeeded by Kepler who worked there for many years. The Technical Museum is excellent. The following itinerary is taken from the "Handbook of Student Travel."[28]

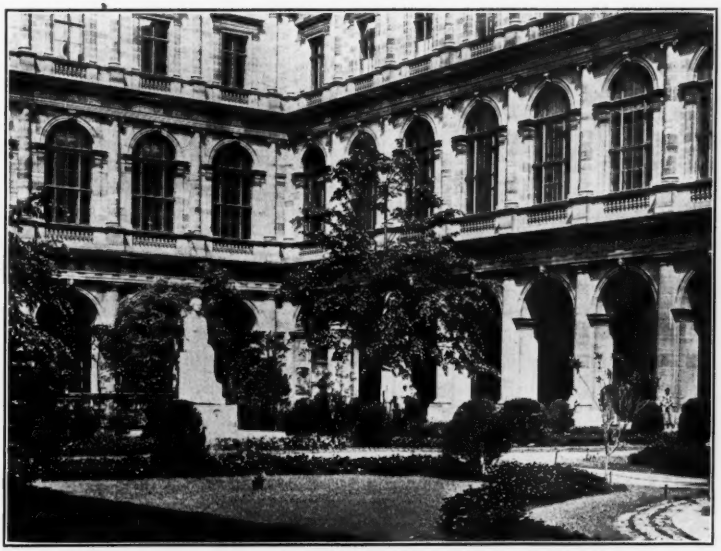
Prague—Glass factory and milk industry; Chemical Laboratories of Technical High School and Sugar Institute.
Kladno—Coal mines.
Beroun—Sugar factories and blast furnaces.
Plzen—The Skoda Works, brewery; Kaolin industry.
Jackymov (Joachimstal)—Radium works.
Kralupy—Mineral oil refinery.
Budejovice—Pencils and graphite; matches.
Cesky Krumlov—Paper mills.
Turnov—Glass factories.
Hradec Králové—Foodstuffs and leather.
Prerov—Artificial fertilizers.
Vitkovice—Iron works and chemicals.

The caverns and grottoes at Blansko contain wonderful stalactites and stalagmites.

Austria

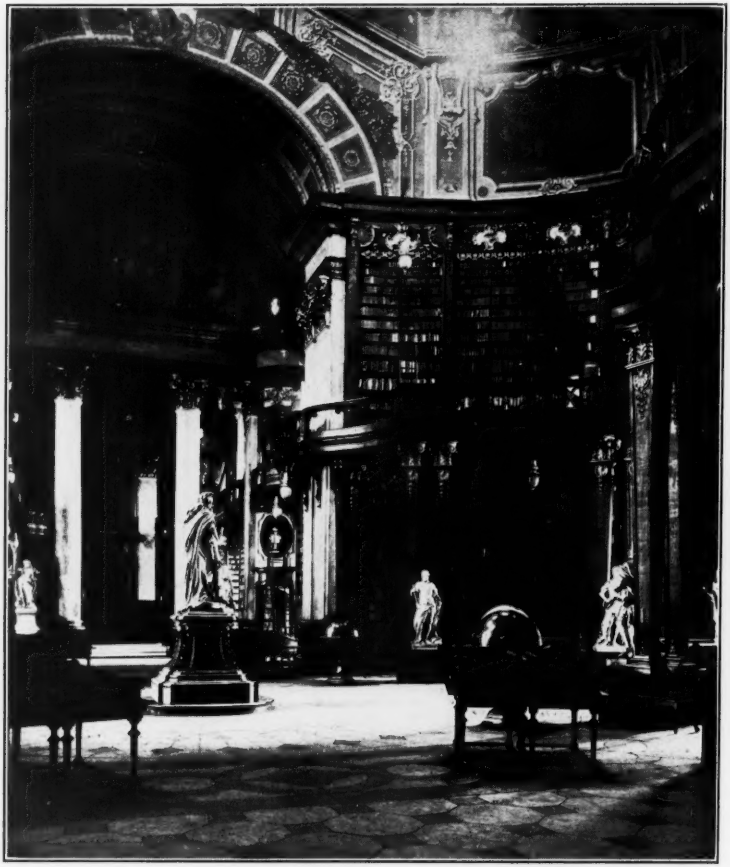
The Viennese schools of medicine have long overshadowed the instructional facilities in other branches of science, but the latter have not been neglected in this marvelous center of art, music, and education. The University of Vienna possesses two chemical Institutes, each with separate faculty. One is headed by Wegscheider, the other by Spaeth. There is also an Institute of Chemical Technology devoted primarily to the training of dye chemists.[29] All of these are suffering from lack of funds. The laboratory of Wolfgang Pauli contains much interesting apparatus for

UNIVERSITY OF VIENNA—FESTIVAL HALL



UNIVERSITY OF VIENNA—INNER "ARKADEN" COURT

colloid and biochemical work. The laboratories of the Technical High School are well equipped. Of the many collections in Vienna, the scientist will find those in the Natural History Museum of greatest interest, particularly the sections devoted to mineralogy, geology, zoölogy, and botany.

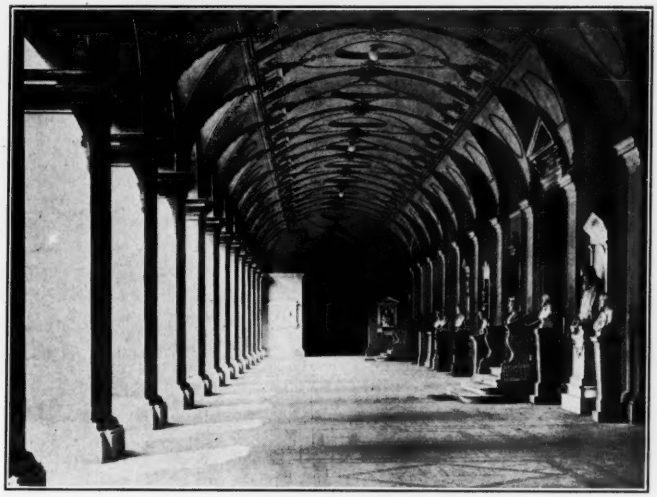


INTERIOR OF NATIONAL LIBRARY, VIENNA

The Technical Museum depicts the historical development of technology, though chemistry is rather weak. The National Library, housed in a beautiful building, contains 1,200,000 volumes. The Museum of the History of Medicine contains much of interest to students of general science.

The University at Graz is known to chemists chiefly because of F.

THE UNIVERSITY, VIENNA



"ARKADEN" COURT OF THE UNIVERSITY OF VIENNA. "ARKADEN" CORRIDOR
Entrance to the library at the end.

Pregl's work on micro-analysis. Paracelsus died at Salzburg (1541) and his grave may be seen in the cemetery of the Hospital of St. Sebastian.

Acknowledgment

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HISTORY OF ART MUSEUM (LEFT) AND NATURAL HISTORY MUSEUM (RIGHT), VIENNA
In foreground the Outer Door of the Imperial Palace.

Hendrick; Ernest Strathmann; The German Railroads; Swedish State Railroads; Swiss Federal Railroads; Austrian Federal Railroads; The National Student Federation; The World Peace Foundation; Institute of International Education.

The compiler acknowledges their aid with thanks.

NOTES

References to pertinent papers that have appeared in THIS JOURNAL have been interspersed throughout the body of this article, not only for their content, but also for the illustrations.

[1] L. C. Newell, "Faraday's Discovery of Benzene," **3,** 1248–53 (Nov., 1926).

[2] F. G. Donnan, "The Chemical Department at University College, London," **4,** 819–21 (July, 1927).

[3] W. A. Patrick, "Impressions of the Old Chemical Laboratory at University College, London," **4,** 817–8 (July, 1927).

[4] A. Hopwood, "John Dalton," **3,** 485–91 (May, 1926); H. F. Coward, "John Dalton," **4,** 23–37 (Jan., 1927).

[5] C. A. Browne, "Priestley's Life in Northumberland," **4,** 159–72 (Feb., 1927).

Contains illustrations of Priestley's house (p. 168) and monument at Birmingham (p. 169).

[6] J. Walker, "The Chemistry Department of the University of Edinburgh," **4,** 570–3 (May, 1927); J. Kendall, "The University of Edinburgh," **4,** 565–9 (May, 1927).

[7] S. E. Sheppard, "The Chemistry of Photography. I. Historical Considerations," **4,** 298–312 (Mar., 1927).

[8] P. Sabatier, "La Chimie Moderne et Marcellin Berthelot," **3,** 1099–102 (Oct., 1926); A. A. Ashdown, "Marcellin Berthelot," **4,** 1217 (Oct., 1927).

[9] W. Foster, "Chemistry in the French Lycees," **2,** 43–6 (Jan., 1925).

[10] A. Seidell, "Chemical Research at the Pasteur Institute," **3,** 1217–39 (Nov., 1926).

[11] L. Darmstaedter and R. E. Oesper, "Emil Fischer," **5,** 37–42 (Jan., 1928).

[12] F. Paneth, "The Teaching of Chemistry in the German Universities," **5,** 705–10 (June, 1928).

[13] K. Freudenberg, "The Study of Chemistry at Heidelberg. A Glimpse of an Historic Home of Research," **4,** 441–6 (Apr., 1927).

[14] R. E. Oesper, "Robert Wilhelm Bunsen," **4,** 431–9 (Apr., 1927).

[15] R. E. Oesper, "Justus von Liebig, Student and Teacher," **4,** 1461–76 (Dec., 1927).

[16] L. Darmstaedter and R. E. Oesper, "August Kekulé," **4,** 697–702 (June, 1927).

[17] R. E. Oesper, "Karl Friedrich Mohr," **4,** 1357–63; grave, p. 1362 (Nov., 1927).

[18] P. Pfeiffer, "Alfred Werner," **5,** 1090–8 (Sept., 1928).

[19] N. Parravano, "Centenary of Cannizzaro and the Atomic Theory," **4,** 836–44 (July, 1927).

[20] N. E. Gordon, "Poland, a Country with a Chemical Future," **4,** 1386–98 (Nov., 1927).

[21] E. R. Caley, "The Stockholm Papyrus," **4,** 979–1002 (Aug., 1927).

[22] The Nobel Prizes in Chemistry have been awarded to J. H. van't Hoff, Berlin (1901); E. Fischer, Berlin (1902); S. A. Arrhenius, Stockholm (1903); Sir William Ramsay, London (1904); A. von Baeyer, Munich (1905); H. Moissan, Paris (1906); E. Buchner, Berlin (1907); E. Rutherford, Manchester (1908); W. Ostwald, Leipsic (1909); O. Wallach, Göttingen (1910); Marie Curie, Paris (1911); V. Grignard, Nancy, and P. Sabatier, Toulouse (1912); A. Werner, Zürich (1913); T. W. Richards, Cambridge, Mass. (1914); R. Willstätter, Munich (1915); F. Haber, Berlin-Dahlem (1918); W. Nernst, Berlin (1920); F. Soddy, Oxford (1921); F. Aston, Cambridge (1922); Fritz Pregl, Craz, Austria (1923); R. Zsigmondy, Göttingen (1925); The Svedberg, Sweden (1926); H. Wieland, Munich (1927); A. Windaus, Göttingen (1928).

[23] T. L. Davis, "Boerhaave's Account of Paracelsus and Van Helmont," **5,** 671–81 (June, 1928).

[24] E. R. Caley, "The Leyden Papyrus," **3,** 1149–66 (Oct., 1926).

[25] E. M. Chamot and C. W. Mason, "Chemical Microscopy. II," **5,** 258–68 (Mar., 1928).

[26] F. Lambermont, "The New Laboratories of the Brussels Polytechnic School," **5,** 64–71 (Jan., 1928).

[27] H. N. Holmes, "The Street of the Alchemists," **5,** 467–8 (Apr., 1928).

[28] This publication may be purchased ($1.00) from the National Student Federation, 218 Madison Avenue, New York. It contains much valuable information for students and teachers planning to tour or study Europe.

[29] J. S. Reese, "Chemical Education in University of Vienna," **5,** 1124–8 (Sept., 1928).

UPPSALA RECOLLECTIONS[1]

FRANCIS F. HEYROTH, UNIVERSITY OF CINCINNATI, CINCINNATI, OHIO

It would be difficult to imagine a more charming and stimulating situation for a laboratory than that occupied by the two chemical buildings of the renowned Uppsala University, which, it may be recalled, celebrated in 1927 its 450th anniversary. A large wooded park, especially beautiful when its many oak, lime, and beech trees are covered with snow, separates the buildings from the University Library, known in compliment to Karl XIV Johan as the Carolina Rediviva. To the south of the chemistry buildings, beyond a long brick wall, is a large, partly terraced botanical garden arranged in French style and possessing much to remind the visitor

UPPSALA UNIVERSITY : MAIN BUILDING
The university was founded in 1478 and is the oldest and largest in Sweden.

of Carl von Linné, who lived and worked in Uppsala. Tall hedges in the shaded cemetery on the north surround the grave of Svante Arrhenius. Students, even those but casually acquainted with the history of chemistry, cannot fail to be deeply impressed on passing the entrance of *Nya Kemikum*, surmounted as it is by the busts of Torbern Bergman, Jacob Berzelius, and Carl Scheele. Mementoes of the great men who have lived in Uppsala remain in many sections of the city. At the central square an apothecary shop is still to be found in the house (marked by a tablet) in which Scheele made many of his most notable discoveries. A few blocks distant is the botanical garden and residence of Linné, and

[1] Based on the experience of the author as Medical Fellow of the National Research Council, in the laboratory of Professor The Svedberg.

nearby is a house in which Celsius, of thermometer fame, set up an astronomical observatory.

Nearer our day, other men, some of whom are still living, contributed to uphold the fame of Uppsala as a chemical center. Especially noteworthy in the last part of the past century was the development of physiological chemistry under the leadership of Olaf Hammarsten, author of the widely used text, and Sven Hedin, his successor, pensioned in 1924. This department, at present under the direction of Carl Mörner, finds its home in the older building, erected in 1859.

The newer laboratory houses the work in all the other branches of chemistry. Within it, approximately two hundred students[2] receive instruction during each year. Because of the semi-graduate nature of even the younger students, there are no laboratories designed for the teaching of elementary chemistry to large classes. Many students attend only lectures or rather intensive laboratory courses of but a few weeks' duration. Students in these introductory courses customarily work in the laboratory from ten in the morning to two in the afternoon, and are expected to use the remainder of the day for collateral reading. But one course is taken at a time.

The peculiar system of secondary education in Sweden (at present in a state of flux) is such that a pupil may take either a Realskol course of six classes, which does not admit to the universities, or, beginning with the sixth class, may superpose upon the lower five a four-class *Gymnasium* course which culminates in the rigorous *student examen*, the successful passage of which admits to the universities. Gymnasia pupils have the choice of either *real* (natural science) or Latin *lines*, the former embracing French, elements of philosophy, mathematics, biology, physics, and chemistry. Standards are high throughout the course. The *student examen* comprises written and oral parts. The former is set by a Central Board in Stockholm and is of a degree of difficulty comparable with those of our introductory college courses in these subjects. The oral examination covers many subjects of the four classes and is conducted some weeks later by the pupils' own teachers, each in his respective subjects. This ordeal occurs in the presence of the public and of a board of non-local

[2] Uppsala, the larger of the two Swedish State Universities, has a few more than 3000 students, nearly 400 of whom are women; the other at Lund has 2000 students. There are also in Sweden two smaller colleges, one at Stockholm and the other at Gothenburg, with 1200 and 350 students, respectively. At Stockholm is also the Royal Caroline Medico-Surgical Institute, with over 800 students. Much highly significant work in biological chemistry, particularly in the field of enzyme reactions, is in progress in Stockholm, largely under the direction of Professor Euler, whose institute has recently received a large grant from the Rockefeller Foundation. There are also in Sweden technical high schools and several state schools for instruction in agriculture, forestry, mining, etc.

censors who may, if they see fit, take over the questioning. Failure to pass this exacting test is not uncommon. Those who pass are thenceforth known as *students*, and vary in age from eighteen to twenty. Most are presented with flowers, and many are carried on the shoulders of their friends from the examination rooms to hat stores from which they may now take the previously ordered white velvet caps by which Scandinavian students are identified. The few remaining open cabs and many flower-laden open cars carrying shouting and singing groups of the new students and their friends fill the streets of the Swedish towns, enlivening them for hours with countless repetitions of a song, beginning:

> Sing of the students' happy day.
> Let us rejoice in the springtime of youth.
> A clear, strong beat of the heart,
> And the new-dawning future is ours.

The universities are open to foreign students who have completed their matriculation in some recognized university, or who are able to satisfy the professors under whom they desire to work that they are equipped to do so profitably. They may not, however, take examinations except by permission of the King in Council. Non-Swedish students are obviously unable to profit by listening to lectures and usually desire to engage in definite investigations under the direction of some one of the professors or docents, all of whom speak English.

There are only nominal laboratory and breakage fees to be paid to the university. Certain courses are free; others carry fees varying from four to eight dollars. There is usually a charge of about three dollars for an official letter identifying the matriculant as a student, and small voluntary fees each term are divided among the caretakers of the laboratories.

All students, and foreigners are usually included, are required to become members of a *nation* or student club, through the officers of which the students usually conduct their official business with the university. There are in Uppsala thirteen of these clubs, each with a geographical designation; students are usually elected into the *nation* into which the locations of their homes would naturally place them. They do not live in the *nation* houses, some of which are elaborate and valuable pieces of property. These serve rather as club and reading rooms and as social centers. The fees for initiation and dues vary in the different *nations*. A foreign student usually chooses to join one in which certain of his laboratory associates happen to be members. The foreigner desirous of learning something of Swedish student life should avail himself of the opportunities for contacts offered by these clubs, but will of course be greatly handicapped

without a knowledge of the language. Most students, however, have at least a slight knowledge of English.

The laboratory with which the writer is most familiar, that of physical chemistry, has been under the direction of Professor Theodore (or, as he prefers to be known, The) Svedberg since his appointment as professor in 1912 at the early age of twenty-eight. His lectures in the autumn of 1927 dealt with certain aspects of the phase rule and the equilibria in heterogeneous systems. This choice of subject matter is interesting in view of the fact that Professor Svedberg is known as one of the three chemists whose investigations of colloidal systems have been rewarded by the Nobel Prize. That a laboratory devoted for years to the study of colloids should be designated as a laboratory of physical chemistry compels attention to the belief which dominates it: progress in the investigation of colloidal systems can best be attained by accurately characterizing them in terms of the results of exact measurements of their properties by the best available physical and chemical methods. For years Professor Svedberg has pointed out the need for new tools and new methods for attaining this end and has, with boldness and persistence and extraordinary ingenuity, devoted himself to this task.

PROFESSOR THE SVEDBERG

The earlier investigations in this laboratory were concerned with the conditions determining the formation of inorganic colloidal systems. Since 1909 attention has been devoted to the development of methods for the determination of the distribution of the sizes of the particles in such systems. Docent Herman Rindé in 1928 defended a doctor's dissertation in which there was outlined the gradual development of apparatus by which such determinations might be made in the case of gold sols. During a period of several years a number of methods were suggested by various workers for the solution of this problem, the necessary apparatus designed and at considerable expense constructed, and in some cases discarded and replaced by other and better methods as they became available. These efforts culminated in the construction of the ultracentrifuge for the determination of the distribution of the sizes of colloidal particles by studying by photographic methods the concentration of the colloid in various portions of a cell maintained in a field of high centrifugal force. During these

studies the applicability of the method to the investigation of the proteins became apparent. It was soon demonstrated that these important substances appear to be, under all but unusual conditions, definite chemical individuals possessing determinable molecular weights of great magnitude. Thus for the hemocyanin of the snail a value of five million was obtained. In the cases of proteins which had been studied by other investigators by familiar methods, good checks were obtained by this new method, the values found for the commoner proteins ranging from 34,000 to 200,000. Thus far twelve proteins have been studied at Uppsala under a wide variety of conditions; the results in the case of seven have already been published in the *Journal of the American Chemical Society*

Foreign students trained in mathematics and physical chemistry are welcomed in the laboratory and are given problems in this field. As there are usually but five or six students engaged in this work, Americans may expect to receive a larger measure of the personal attention of the professor than is likely to be the case in laboratories doing more varied types of work and accommodating a larger number of students. Newcomers are aided most graciously in meeting the difficulties attending their first few days in a non-English speaking town by the assistant in the department, Arne Tiselius, who freely devotes his time to helping them secure comfortable quarters. One or more foreign students are usually included among the workers of the laboratory, and there are usually others in Professor Siegbahn's Institute for Physics, nearby.

The development of much space-consuming apparatus unavoidably led to the overcrowding of the laboratory, and made it necessary to utilize space in several inconveniently accessible portions of the building. This condition will within a year or so be remedied by the completion of a new building now under construction to house the laboratory of physical chemistry.

Students with little mechanical experience may find working with the somewhat complicated oil-turbine centrifuge quite difficult. It is apt to be confusing at first to attempt to photograph, at ten- to twenty-minute intervals during a period of two to three hours, a protein solution contained in a quartz cell enclosed in a steel rotor of 15 cm. diameter rotating at 42,000 r. p. m. in an atmosphere of hydrogen at 13 mm. pressure, and to make during this time the many readings and adjustments necessary to control the temperature, gas pressure, and speed of the apparatus. But Professor Svedberg is always willing to explain the details of its operation and to work with the student until he has acquired confidence in his ability to start and stop this somewhat terrifying piece of equipment. The skilled mechanics of the laboratory are also quick to appreciate the difficulties of the newcomer, although they speak no English.

A certain understanding of photographic theory and technic is essential

to success in this work. This can be acquired at Uppsala by performing certain of the exercises which are included in the introductory course in physical chemistry, which emphasizes the subject to an unusual degree. A stay of less than two semesters is not likely to prove profitable, as the technic requires a number of operations unfamiliar to most workers. A stay of two years would be more satisfactory if it could be arranged.

It is not likely that many would find this too long a time to pass pleasantly in Sweden. Although the winter is long, the temperature is not commonly much, if any, lower in Uppsala than in New England. Rooms are well heated either by tile stoves or by steam heat. Excellent food is obtainable at moderate monthly rates (ordinarily less than a dollar a day) at the hotels. One selects from a central table the kind and amount of food desired. The meals are, however, served at what seem to foreigners rather strange hours: breakfast, 8:30–12:00, dinner, 3:00–6:00, supper, 8:00–10:00. At breakfast and supper are included (besides other dishes) the characteristic *smörgåsbord*, or buffet of bread, butter, cheese, fish, meatballs, salad, etc. The people are noted for their hospitality to foreigners, and most visiting students find it impossible to remain a few months in Uppsala without forming friendships. Although Uppsala has but 30,000 dwellers, Stockholm, with opera, theatre, and parks, is only about an hour away. The nature of the work is such as to require a long day, and but little leisure is available.

Swedish students vary greatly in age. Most of them dress with a degree of formality to which our students are unaccustomed, are in general mature, and impress the Americans as quiet and somewhat reserved. Even boys of twenty customarily carry walking sticks. Highly conventional forms of address, emphasizing the status of the individual spoken to as *kandidat*, *licentiat*, *magister*, or *doktor* are obligatory, except among intimates. By temperament the students are critical, both of themselves and of others, and their appraisals of persons or events are candid. Many organizations exist to further the most varied activities. Competitive sports are usually under the auspices of private clubs, and are not a prominent feature of student life, although the characteristic forms of instruction in Swedish gymnastics are highly developed. Skiing, skating, and hunting are commonly enjoyed. Besides giving the spring concert at the annual festival of the University, the noteworthy *Sång-kår* participates during the year in at least three out-door celebrations.

On the evening of November 6th, the anniversary of the death of Gustaf Adolf, this formally dressed, silk-hatted group marches from the Library to an obelisk commemorating that leader in the nearby Odinslund, to sing a few songs and listen to a short talk by one of their number. A similar ceremony is observed on the 30th of November in honor of Karl XII, the military hero and popular idol whose reign, however, was almost

catastrophic. This time the students carry torches as they march through the crowded streets to an old house, bridging a street, known as the Skytteanum after its owner in 1600, Johan Skytte. After songs here, the march continues across the narrow Fyris river, into which the torches are thrown from the bridge.

A celebration in striking contrast to the somewhat stilted dignity of the two just described is that by which farewell is taken of winter on *Valborgsmassafton*, Walpurgis night, the 30th of April. At precisely 3 P.M. all students, no matter where they may be, don their student caps, which during the winter are worn only on formal occasions, as for example the funeral of a professor. As the hour of three approaches a spirit of jubilation fills the air, and both students and townspeople throng to the river bank. Soon about two thousand white caps appear, old winter hats of varied styles are thrown into the river, and after floating a few rods become the property of boys and old men who fish them out with boathooks. The crowd becomes noisy, parades are hastily organized, a ring of dancing students encircles a helplessly protesting policeman who has incurred their disfavor. Old cabs, taxis, private cars are filled with shouting students and thread their way through the crowded streets. At the various hotels dinners are eaten by the white-capped students, wines and liqueurs flow freely, and the entire character of the student life changes for the day. At nine the students meet at the central square about the standards of their *nations*, and parade up the hill to the castle where as darkness approaches the *kår* sings to the departure of winter and the coming of spring. From the hilltop, many large signal fires, lighted at various outlying districts, now become visible. The groups march to the *nation* houses where, after dining and drinking, records of the year are read, formal speeches are made, burlesques are played, and student songs, including the universal Gaudeamus, are sung. The spirit of rivalry prompts one or another club to straggle as a group as dawn appears to the home of another club, and there to listen to a duel of wits between two representatives of the groups selected for their skill at repartee. For one or two days the University buildings are deserted; then the student life resumes its outwardly sedate course.

The event of greatest magnitude in the scholastic lives of a relatively small percentage of the students is the defense of a thesis for the doctorate. This formal occasion is open to the public and attracts many of the younger students. Copies of the thesis are available to each of the spectators, who are enabled to follow from page to page the criticisms of the opponents representing the University. These men have for days searched for errors of fact, of method, of expression, or even of typesetting. After answering during four hours the rigorous criticisms of his work, the author has the privilege of stopping the proceedings. It is customary for every one who

takes an examination, even of the lower grades, to give a dinner to some of his friends. Last winter the writer had the privilege of attending an unforgettable doctor's dinner given by Docent Rindé to about sixty men in the hall of one of the student clubs. All guests were attired in full evening dress, and several presented the host with flowers. Opponents and candidate drank to each other after witty speeches, and formal thanks were expressed to all who had even in the slightest degree been of assistance during the preparation of the thesis. It has been rumored that some aspiring doctors proffer *corruption dinners* to their opponents in advance of the examinations. At the formal *promotion* or graduation ceremony in the spring, formal dress and not the academic cap and gown is worn. Each new doctor is crowned with a laurel wreath. As it is placed upon his brow, a cannon outside, timed with unerring accuracy, proclaims to the city the advent of a new doctor of philosophy.

UNITED STATES CIVIL-SERVICE EXAMINATION

The United States Civil-Service Commission announces an open competitive examination for Assistant Chemist. Applications must be on file with the Civil-Service Commission at Washington, D. C., not later than March 6th.

The examination is to fill vacancies in the Departmental Service, Washington, D. C., and in the field.

The entrance salary in the District of Columbia is $2600 a year. A probationary period of six months is required; advancement after that depends upon individual efficiency, increased usefulness, and the occurrence of vacancies in higher positions. For appointment outside of Washington, D. C., the salary will be approximately the same.

Optional subjects are advanced inorganic chemistry, analytical chemistry, organic chemistry, and physical chemistry.

Competitors will not be required to report for examination at any place, but will be rated on their education, training, and experience, and publication or thesis to be filed by the applicant.

Full information may be obtained from the United States Civil-Service Commission, Washington, D. C., or the secretary of the United States Civil-Service Board of Examiners at the post office or customhouse in any city.

Copper and Zinc Salts Redeem Florida Muck. Copper is usually thought of as a poison to plants, but used in combination with zinc it is the salvation of the raw sawgrass soils of the Everglades when these are to be planted in peanuts, according to R. V. Allison and J. H. Hunter of the University of Florida Agricultural Experiment Station at Belle Glade, who recently reported their researches before the American Society of Plant Physiologists.

The two experimenters found that copper sulfate alone, which has given considerable success in tanning new, broken Everglades land for other crops, held back the growth of peanut plants, but when a zinc salt was added good effects followed immediately.—*Science Service*

MATHEMATICAL REQUIREMENTS FOR PHYSICAL CHEMISTRY*

FARRINGTON DANIELS, UNIVERSITY OF WISCONSIN, MADISON, WISCONSIN

Chemistry has graduated from the class of descriptive sciences into the class of exact, mathematical sciences. This development has taken place so fast that the training of chemists in mathematics has not kept pace. Inadequate preparation in mathematics now constitutes the greatest problem in the teaching of physical chemistry.

The following quotations are offered in support of these statements. Crum Brown stated in 1892:

> Unless the chemist learns the language of mathematics, he will become a provincial and the higher branches of chemical work, that require reason as well as skill, will gradually pass out of his hands.

After quoting this statement, James Kendall goes on to say:

> Such a statement regarded then as sensational would now pass unnoticed as a platitude. Whether he likes it or not, every physical chemist of the present time must also be a mathematician. The actual amount of formal mathematics which it is essential for him to assimilate is not large, but he must be able to use every particle of it with a clear understanding.

In emphasizing the mathematical weakness of chemical training, J. R. Partington says:

> Exactly why the student of chemistry is always assumed to have much weaker equipment than other students it is difficult to say, but the fact remains that it is always customary to proceed on this assumption and to take care that when his delicate constitution is to be subjected to small doses of mathematics, these are always well diluted with neutral matter.

Speaking of the older physical chemistry, E. W. Washburn says that it was customary to adopt

> . . . a somewhat apologetic attitude and to explain that the student must take on faith 'these few derivations,' but that he should not allow this fact to worry him.

He goes on to say that, in a modern course in physical chemistry,

> . . . calculus is freely employed and the student is strongly advised to acquire the elements of calculus before attempting to secure any special training in physical chemistry.

Pointing out that freshman chemistry now embraces physical chemistry as given a generation ago, H. S. Taylor states that:

* Contribution to the symposium on "The Teaching of Physical Chemistry," held by Divisions of Physical and Inorganic Chemistry and Chemical Education, at the 76th Meeting of the A. C. S., September 11, 1928, at Swampscott, Mass.

> Physical chemistry...is offered the possibility of substituting for the descriptive, qualitative course a more rigorous and therefore more mathematical discipline...Any teacher who would advise his students that he can attain to an understanding of the science as now developing without the mathematical knowledge, is doing an ill service to his pupils.

Professor T. W Richards said:

> I am a thorough believer in sound mathematical treatment and I feel that positive knowledge is not available until one has a satisfactory mathematical expression of his problem.

Professor Richards also sounded a very necessary warning as follows:

> Such a viewpoint....is entirely consistent with profound mistrust of mathematics based upon inadequate premises.

The task of the mathematical chemist is indeed more difficult than that of the mathematician for the test tube imposes many restrictions that are unknown to the pure mathematician.

After emphasizing the present trend toward mathematics in chemistry the mathematical requirements for an elementary course in physical chemistry will now be reviewed briefly. The student must be able to juggle algebraic formulas and put them into the form which is necessary for any particular purpose and he must be able to solve quadratic equations.

The ability to handle large and small numbers is essential because important advances are now being made by visualizing the individual units of matter, electricity, and radiation. For example, it used to be sufficient to say that oxygen is sixteen times as heavy as hydrogen but now we know that each atom of oxygen weighs exactly 2.64×10^{-23} gram. It is taught that 96,500 coulombs of electricity is associated with the electrolysis of a gram equivalent. This relation is known as Faraday's law and the 95,000 coulombs was formerly accepted merely as an empirical constant. Now we know that this constant is theoretically significant and is obtained by simply multiplying the charge on an electron (1.59×10^{-19}) by the number of atoms in a gram atom (6.06×10^{23}). The Planck constant, 6.57×10^{-27}, is important in all quantum calculations. The student easily masters the exponential notation and acquires the ability to handle these large and small numbers.

Logarithmic equations are extensively used by the chemist but the physicist usually employs exponential equations. The student of physical chemistry must be able to solve either and he must be able to transform one into the other. He should not hesitate to find the value of $e^{-\frac{20,000}{RT}}$ when R and T are given. Negative logarithms are met with frequently in electrochemistry and particularly in the treatment of hydrogen-ion

concentration, as pH. Many students are bothered by these calculations and do not seem to realize, for example, that in logarithms:

$$-6.70 = \bar{7}.30 \text{ or } 3.30 - 10$$

Every chemist should use a slide rule not only for the sake of increased speed and efficiency but also for the training which it gives in the evaluation of significant figures. A user of the slide rule is not likely to divide 40.0 cc. by 30.0 cc. and write a normality factor of 1.333333.

The student should plan his experimental graphs so as to utilize most of his coördinate paper. Frequently he becomes confused if he cannot start his scales at zero and use the same scale along each axis.

The finding of an empirical equation for a set of data is an important art. Experience in curve fitting would be welcomed by the chemist in analytical geometry. The most useful empirical equations, aside from straight line equations, are the parabolic equation: $y = a + bx + cx^2$, and the semilogarithmic equation: $\log y = bx + c$. The student is much impressed when he obtains data in the laboratory, as, for example, the vapor pressure of a liquid at different temperatures, plots a curve and finds its equation and then finds that the empirical constants can be derived from theoretical considerations.

Calculus is absolutely essential. Simple differentiations, integrations, integration between limits, and the use of integration tables are all necessary. As a rule the preparation in calculus is sufficient for the meager demands of physical chemistry but the students seem to lack confidence. The cause of this lack of confidence is not easy to understand. It may be that the instructor in chemistry himself lacks confidence or it may be that the student thinks that the chief aim of calculus is to memorize half a hundred rules of differentiation and integration. The teacher of physical chemistry does not expect that the students will remember many of these rules but he does want them to understand the principles and to be able to think in terms of calculus.

The compound interest law runs through many branches of physical chemistry and it should be clearly understood.

Differential equations are used frequently but usually they are so simple that the student does not realize that he is solving differential equations. The commonest examples are the van't Hoff reaction isochore:

$$\frac{d \ln K}{dT} = \frac{Q}{RT^2}$$

and reaction rates such as:

$$\frac{dx}{dt} = k\,(a - x)\,(b - x)$$

When several reactions are proceeding simultaneously more complicated differential equations are needed. Partial differentiation is the backbone of thermodynamical treatment and the student should be able to lay contour lines in every conceivable manner over a three-dimensional graph (pressure, temperature, and volume, for example) and know exactly what he is doing. The physical significance of partial differentiation is the important thing for the student to master.

Partial molal quantities should now be introduced into courses in physical chemistry in order to study adequately the properties of solutions. The mathematical technic and the graphical methods necessary in using and compiling tables of entropy are important also. These newer developments in exact physical chemistry are discussed fully by Lewis and Randall.[1]

Having outlined briefly, then, some of the mathematical requirements for a course in physical chemistry, the question arises as to how these requirements shall be met. Obviously, there is only one satisfactory answer. The student must have had courses in mathematics through integral calculus before he is permitted to take physical chemistry. It is to be hoped in this connection that courses in mathematics will include, along with problems for engineers, some problems especially for chemists, and that some phases of the mathematical training which are of special importance in chemistry will be stressed a little more. The most important contribution of mathematics, however, is not concerned with any specific technic. The chief asset is a mathematical state of mind and it is acquired only after long practice in solving problems.

There is a difficulty in this absolute pre-requisite of calculus. Students in biology and agriculture and geology, for example, should have some physical chemistry but to demand two years of mathematics before starting physical chemistry frequently works an undue hardship on these students or drives them away completely. The same statement may be made concerning academic students who are taking chemistry only as an incidental subject. The subject almost calls for two courses, one for real chemists and one for others. If the inadequately prepared student is admitted to physical chemistry he should do all that he can to study by himself the most necessary parts of mathematics.

It was stated before that inadequate preparation in mathematics is the most serious difficulty in the teaching of physical chemistry. In conclusion a still stronger statement may be made. *Inadequate experience in mathematics is the greatest single handicap in the progress of chemistry in America.*

Suppose that some one should make the statement that "with a few

[1] Lewis and Randall, "Thermodynamics and the Free Energy of Chemical Substances," McGraw-Hill Book Co., New York, 1923.

exceptions the conspicuous advances in theoretical chemistry are now being made by physicists." You would say that it is not true. Then you would think of Bohr, Planck, Einstein, Rutherford, Debye, Franck, and many others and admit that there is some truth in the statement. When you reflect as to the reason, you realize that physicists are better trained in mathematics and that they have expressed our chemical phenomena with mathematical formulas, and that the expression of these formulas has led to the discovery of mechanisms which are of fundamental significance.

Then we would all agree that the oncoming generation of chemists must have a better training in mathematics than the past generation has had.

DISCUSSION

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I am sorry that I got to this meeting only in time to hear the last few remarks of Professor Daniels on mathematics and it may be that the comments I have to make may have been covered by him in his discussion. However, even at the risk of repetition, may I present a few observations on this subject? During the last few years, I have had some experience in teaching rather mathematical subjects to graduate students of chemistry and also to students of physics. It is certainly true that graduate students of chemistry have forgotten most of the mathematics that they ever knew and, what is more discouraging, they have in many cases acquired a fear of the subject. Partial derivatives and second derivatives, for example, frighten them so badly that they are ready to withdraw from any course in which they are used. The same is not true of physics students and I wish to ask the question, "How and where do chemists acquire this fear, while physics students escape it?"

The suggestion that students who naturally like mathematics go into physics while those who are fearful of their ability to use it decide to be chemists may partly answer this question, though I don't believe that it is the complete answer. It is my belief that my professors of chemistry were not able to use mathematics easily themselves and that their advice to me in regard to the amount of mathematical equipment for chemists erred far on the side of too little mathematics. Further, I believe that is the attitude of too many of our teachers of chemistry. Students probably have acquired this nervousness about mathematics from their teachers while undergraduates. There is nothing, it seems to me, which can so effectively prevent this fault as for the professor to handle the mathematics

of physical chemistry with ease himself and to present rigorous mathematics to his students as much as possible without any timorous apologies, but with the attitude "of course everyone understands this." We should not make the subject too difficult, but also we should not "sugar coat" mathematics. Physical chemists with a bachelor's degree should have had mathematics through differential equations, and problems of physical chemistry which naturally require the use of such mathematics should be handled fearlessly and as a matter of course by its use.

Blood Chemistry Determines Degree of Drug Action. The effect of a dose of medicine depends not merely on the chemical makeup of the medicine itself but on the chemical state of the blood in our bodies when we take it. This is indicated by the experiments of Dr. William Salant, of the University of Georgia Medical School, performed at the University and at the Cold Spring Harbor Biological Station on Long Island.

The blood of all warm-blooded animals is normally slightly alkaline. When Dr. Salant injected doses of the drug ergotamin into experimental animals whose blood alkalinity had been artificially reduced, a marked depression in their blood pressure resulted. It was possible to restore the pressure to normal or even to increase it beyond that point, simply by controlling the degree of alkalinity of the blood.

The effects of a drug depend not only on the alkalinity of the blood but also on the particular balance of certain elements. Dr. Salant has found that the concentrations of calcium and potassium in the blood are of especial significance in this respect. If the blood is lacking in calcium, adrenalin, a powerful stimulant and energy-releasing secretion, cannot produce results. Even a considerable reduction in the calcium content inhibits the action of adrenalin, unless the potassium present is correspondingly reduced.

If much potassium is present, the poisonous effects of nicotin are greatly increased; and in the presence of an excess of potassium the usually stimulating adrenalin reverses its behavior and becomes a depressant.

The toxicity of mercury is greatly increased by reducing the calcium concentration in the blood. But if the calcium content is increased, the resistance to this poison, and also to arsenic, is correspondingly increased. This point may eventually become one of importance in medical practice, because both mercury and arsenic, though poisonous, are widely used in medicine, especially in the treatment of syphilis. The diet of the patient, in so far as it affects the potassium and calcium content of his body fluids, becomes a matter of concern in the light of Dr. Salant's researches. It is recognized that the average American diet is very low in calcium.—*Science Service*

Tiny Island Yields Huge Phosphate Supply. Phosphate cargoes bulking over a quarter of a million tons a year are now being shipped from Nauru, a small island only 26 miles south of the equator, whose resources are being exploited by Australians. The phosphate is marketed in Australia, New Zealand, and Japan.

Some thousands of Kanaka and Chinese laborers are employed in the workings, their labor supervised by a force of 100 to 120 Europeans. The latter are recruited mainly in Australia. They "take on" for a two-year "hitch," which takes them into a virtual exile, relieved by such comforts as a bachelors' club in the tropics may have to offer.—*Science Service*

THE PROBLEM METHOD OF TEACHING PHYSICAL CHEMISTRY*

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One may acquire enthusiasm for the game of tennis by watching a Bill Tilden play. In order to have a chance of defeating him, however, one must step from the bleachers to the courts and be taught how to swing a racquet.

It is the same with Physical Chemistry. A student may acquire enthusiasm by attending a course of lectures presented by some outstanding leader in the field of chemistry. But in order to "play the game" of chemistry, he must be taught to apply chemical principles to the practical problems of every day. I, personally, believe that this result is best achieved by a well-planned problem course of instruction. I can perhaps best express my views by outlining briefly the type of course which has been developed by Dr. A. A. Noyes and me for college students who have already had good general courses in physics, mathematics, and chemistry.

The course is planned not merely to impart information, but to make the student think about the principles presented by demanding that he work out for himself the method of treatment of special cases on the basis of these principles.

In explaining the nature of the course to my own students I address them somewhat as follows: "In order to become a good practical chemist you must not only know what the fundamental principles of chemistry are, but you must acquire the ability to apply these principles. This ability can be acquired only by your own personal effort, but I can help you by assigning carefully selected concrete problems involving the principles. You will find that these problems are not merely supplementary or incidental to the text, but are the main feature about which the whole presentation centers. They are not grouped at the end of a chapter, but are interspersed throughout the text. As a rule they are not the usual type of problem involving substitution in an equation and mathematical operations, but will require clear logical thinking in the application of the principles under consideration. In other words, it is a *problem course of instruction*, not merely a *course with problems*. You may not be able to solve every problem, but you will gain from having given thought to it, (just as you gain most in tennis by playing with some one who can beat you). My rôle as teacher will be mainly to act as guide and to help you help yourselves."

* Contribution to the symposium on "The Teaching of Physical Chemistry," held by Divisions of Physical and Inorganic Chemistry and Chemical Education, at the 76th Meeting of the A. C. S., September 11, 1928, at Swampscott, Mass.

These problems form the basis of the classroom discussion. Definite problems are assigned which are to be solved and handed in at the beginning of each exercise. My own procedure is to solve the problems on the blackboard, questioning the class as to how to proceed. It has been our aim to make each problem serve a definite purpose, this purpose being indicated by giving each problem (or problem group) a title. It is therefore not difficult to lead the class into a general discussion of principles. In a successful exercise the individual members of the class may ask rather difficult questions. As a rule I appeal to the better men in the class to answer. If I myself am unable to answer the question satisfactorily, I freely admit my ignorance but always try at the next exercise to clear up all doubtful points. In the course of my teaching I have learned a great deal from my students in this way, and I like to think of my course as a "companionate" course of instruction. I do all in my power to foster this spirit. The more difficult problems naturally arouse the most interest. The very simple problems, especially those of the substitution type, are discussed very briefly, if at all.

I ask my students not to take notes in the class. To discourage this habit I point out that the essentials are clearly stated in the text, and that it is far better to give concentrated thought to the discussion during the exercise than to copy down minor facts to be thought about later. The problems which are handed in are marked, but not corrected, and returned promptly to the student. Though I discourage a student from taking notes, I do suggest that he keep a complete file of problems correctly solved.

It is important in a course of this character to give frequent written tests consisting mainly of problems differing from those solved in the class but involving the same principles. This serves not only as an excellent review, but it forces you, as well as your students, to take account of stock, so to speak. In this way any doubtful points are discovered and made clear before new topics are discussed.

At times, when it seems desirable, I lecture informally, but always with the understanding that I am to be interrupted if I do not make myself clear or if any relevant question arises. Of course I reserve the right to judge whether the question is relevant; for one has to deal with the "smart Alec" type of student, and the type unable to put a question clearly. In this way it is possible to allude briefly at least to the experimental, research, and historical aspects of the subject. Collateral reading of reviews and original articles in the chemical periodicals, or of textbooks in which these aspects are more fully discussed, should be definitely suggested. In our revision of "Chemical Principles," Dr. Noyes and I are planning to make definite suggestions, by giving what we call "Reading References" at the end of each chapter. Such references are of special importance to students who are planning to go on to graduate work.

It is very desirable to have this classwork accompanied by a brief laboratory course and by lecture experiments. I believe that the primary purpose of such experiments should be to give concrete illustration of the basic phenomena under consideration rather than to emphasize the experimental methods by which physico-chemical properties are determined. In my own course I have tried to make each experiment resemble a short research so planned that with the apparatus ready at hand, as well as all necessary stock and standard solutions, it may be completed within two or three hours.

Our chief difficulty is to get the student to think about the experiment before he comes to the laboratory, and to prevent him from blindly following directions. Yet we find it necessary to give detailed directions if we are to exact good results in so short a time. We have tried various expedients to insure preparation in advance. The best method, but one difficult to enforce, is to require a data sheet, made out in blank form, in advance. We have also given out problems based on experimental data to be solved. But it is human nature to put off till tomorrow, so we always hold a brief conference in the laboratory in which are discussed the reasons for the details of procedure and the chief sources of errors. Our hope is that the student will then intelligently perform the experiment with but an occasional reference to the directions. A more leisurely attitude toward a laboratory course is much to be desired.

A problem course of this character is necessarily more time-consuming than a descriptive course. For this reason Dr. Noyes and I were forced to omit some of the subjects usually considered in the more descriptive courses. We selected those subjects which we considered of the greatest practical importance to chemists. We first develop the atomic, kinetic, and ionic theories through a consideration of the physical properties related to them, and then with the aid of these theories we present the principles related to the rate and equilibrium of chemical reactions from mass-action, phase, and thermodynamic viewpoints. The very important and fascinating newer theories of atomic structure and radiation we postpone to more advanced courses. You may be interested to know that in our revision of "Chemical Principles" we are planning to publish our book in two volumes; the first covering the elementary part and the second the more advanced. In the second volume we treat more fully thermodynamic chemistry, and hope to develop by the same problem method some of these newer theories.

In conclusion let me state that I am convinced from my own experience that such a problem course does develop in the student the ability to think logically and lays a firm foundation for the more original kind of thinking that goes with research.

AIMS AND VIEWPOINTS IN TEACHING PHYSICO-CHEMICAL PRINCIPLES. THEIR PLACE IN THE CURRICULUM*

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In approaching the problem of the teaching of physical chemistry it seems desirable to propose for the discussion two questions; namely, of what does physical chemistry consist, and what are its present and future aims and purposes?

It is said that J. P. Cooke really began the teaching of physical chemistry in this country in his lectures at Harvard some fifty years ago. He called his subject "chemical physics" and was one of the first to introduce the idea of absolute temperature. Most people, however, would consider that physical chemistry arose as a result of the fundamental researches of van't Hoff, Ostwald, Arrhenius and Nernst in the decade of 1880 to 1890. The birth of the science may be taken as coincident with the founding of the *Zeitschrift fur physikalische Chemie* by Ostwald and van't Hoff in 1887, but the subject had already made much progress a few years previous to 1887.

The novel feature of their investigations was the introduction of physical methods in the investigation of chemical problems. For example, in the case of Ostwald's researches on the rate of reaction, the rate of inversion of cane sugar was followed by the change in polariscopic reading as a means of determining the strengths of various acids.

There was a particular need for the new science, for in 1887 physics and chemistry existed as two entirely separate and distinct sciences with very few points of common interest to span the gulf between them. It was entirely natural therefore that physical chemistry should flourish and develop rapidly as it did. This development has continued to the present time. Within the past fifteen to twenty years, however, it has become increasingly more difficult to maintain the position of physical chemistry as a separate science owing to the manner in which both physics and chemistry have developed.

One of the leading physical chemists of America is credited with saying recently that:[1]

> Physical chemistry exists no longer. The men who have been called physical chemists have developed a large number of useful methods by which the concrete problems of inorganic chemistry, organic chemistry, biochemistry, and technical chemistry may be attacked. As the applications of these methods grow more numerous, it becomes

* Contribution to the symposium on "The Teaching of Physical Chemistry," held by Divisions of Physical and Inorganic Chemistry and Chemical Education, at the 76th Meeting of the A. C. S., September 11, 1928, at Swampscott, Mass.

[1] Author unknown—quoted from W. D. Bancroft, *J. Am. Chem. Soc.*, **48**, 109 (1926).

increasingly difficult to adhere to our older classification. According to this, physical chemistry is essentially a technic and not a point of view.

While I grant that there is some truth in the statement just quoted, yet I do not feel that the development of novel experimental methods—valuable as they have been and will be in the future—constitutes the only goal of modern physical chemistry. If this were the sole purpose of physical chemistry then the subject has seen some of its brightest days and the future prospects would not be encouraging.

The reason why the border lines between physical chemistry and the related sciences are less sharp today than formerly is because of the trend of investigation in both physics and chemistry. At the present time the attention of a great majority of physicists is focused upon what is really a chemical problem, namely, ascertaining the structure of the atom and the correlation of this structure with the individual chemical properties of the various elements. It must be admitted—and much to our regret—that the most conspicuous recent progress in this field of endeavor has been made by men of physical rather than of chemical training.

If the physicist has approached the chemist by entering upon one of his fields of research, chemists as a group without respect to subclassification, under the stimulus of physical chemistry, are using purely physical methods to a much greater extent than previously. For example, instead of determining the acidity of an acid solution by its influence upon the rate of sugar inversion, almost every chemical laboratory worthy of the name, be it designed for industrial or for organic chemical research, is equipped today to make a determination of the pH by determining the electromotive force of a suitable galvanic cell containing the solution in question. Analytical chemistry in particular has profited much by the introduction of the methods of electrometric titration, and similar technics taken directly from physical chemistry.

The net result of these growths in the adjacent sciences is that we no longer have a unique principle with which to distinguish physical chemistry from any other branch of chemistry.

On the other hand, if we ask how are the theoretical methods of physics and chemistry to be taught so that the student of chemistry will be able to combine them successfully, the situation appears in a quite different light. It is for pedagogical reasons that the speaker believes that the existence of a separate science of physical chemistry is best justified.

Although many of the fundamental principles employed are common to both physics and chemistry, the chemist and the physicist still have quite different modes of expression and methods of attacking problems of joint interest. The chemist uses inductive methods principally, whereas the physicist attempts wherever possible to make the development deductive. The result is that the student frequently has much difficulty

in combining the different methods profitably unless both subjects are taught with particular care and with attention to the problems of the sister science. This is not always possible, and the result has been the introduction of definite courses in the curriculum labeled physical chemistry. From a pedagogical standpoint, the need of considering physical chemistry as a special subject can hardly be disputed, that is, if we accept the view that the province of the teacher of physical chemistry is to acquaint the student with *both experimental* and *theoretical* methods from the fields of chemistry and physics which are necessary in the solution of fundamental problems. The subject of solutions furnishes an excellent example. Although this subject has been one of the chief centers of interest from the very beginnings of the science of chemistry, no satisfactory progress in understanding the subject was made until van't Hoff developed his theory of solutions based upon principles and methods borrowed from the field of physics.

If we take an inventory of the various fundamental principles upon which the classical school of physical chemistry has been developed we find that they may be reduced in the final analysis to three cardinal principles.

(*a*) Avogadro's hypothesis, and

(*b*) The first and second laws of thermodynamics.

To be sure, the development of physical chemistry also necessitated employing the principles of stoichiometry; namely,

(*a*) The laws of definite, multiple, and reciprocal proportions, as well as

(*b*) The conservation of mass.

These later principles, however, were part and parcel of chemistry in general and of analytical chemistry in particular, long before the advent of physical chemistry and therefore cannot be credited to physical chemistry as such.

The first and second laws of thermodynamics may rightfully be called foundation stones of physical science and without qualification can be expected to form the basis of physical chemistry for a long time in the future. Avogadro's principle—to borrow an expression of Nernst—is surely also "an inexhaustible horn of plenty."

The Avogadro principle is, of course, looked upon today as a logical result of the assumptions of the kinetic theory of gases and this aspect of the principle should be emphasized, although in the earlier development of physical chemistry it was not stressed at all. Avogadro's principle was developed primarily to interpret the Gay-Lussac-Humboldt law of definite combining volumes, and was accepted in chemistry only because of the success which attended its application to the vexing problem of atomic and equivalent weights, which it solved by furnishing for the first time an exact definition of molecular weight and a means for determining this quantity.

The fruits of the combination of Avogadro's hypothesis and thermodynamics were many. Among some of the more important we may cite:

1. The determination of the degree of dissociation in gases and the proof that these equilibria follow the law of mass action. Although at first the law of mass action was obtained by purely inductive methods it was later shown by writers on thermodynamics, like Max Planck, to be a theoretical consequence of the second law and the Avogadro principle. The writer feels that one of the most important objectives for which the teacher of physical chemistry should strive is that of imparting a clear understanding of the origin and thermodynamic foundation of the law of mass action, in addition to making the student familiar with its applications. It is only when the thermodynamic derivation of the mass law has been adequately grasped that the student is able to understand why the classical mass law works so beautifully in some cases and fails so miserably in others.

2. Van't Hoff's theory of dilute solutions is likewise a result of the combination of the Avogadro principle and thermodynamics, the results for gases being taken directly over by analogy to solutions. Although purely formal in character, Washburn's emphasis upon grouping the van't Hoff laws under the heading of laws of constant thermodynamic environment is a useful one and paves the way for the later treatment of electrolytic solution, where the environment does not remain constant even at very high dilution when the concentration is varied.

3. The third result was Arrhenius' theory of electrolytic dissociation and electrochemistry, for which it is necessary to add Faraday's law of electrical and chemical equivalence.

These topics constituted the meat of the course in physical chemistry as given say twenty years ago. There were of course short and elementary accounts of the meaning and use of van der Waal's equation in the chapter on gases, also a chapter on the phase rule as a means of classifying heterogeneous chemical equilibria, and one on rates of chemical reactions particularly as regards the question of the determination of the order of the reaction. The amount of time devoted to the solid state was generally meager. Aside from applications of the Clapeyron-Clausius equation this chapter usually did not contain much more than a classification of solid bodies according to crystallographic form. Electrochemistry as a rule was set aside as a separate topic and taken up at the end of the course since the results with strong electrolytes did not always fall in line with the treatment, given the question of degree of ionization as computed from the freezing-point calculation then in vogue. In some texts we would find a chapter upon the periodic law, with an elementary treatment of some of the recently discovered facts of radioactivity.

If now we contrast this more or less hypothetical textbook of 15–20

years ago with some that have been published in the past five years, we cannot help being struck by the following changes.

In the first place thermodynamics no longer occupies the unique position which it held previous to 1908. Although its utility remains as great as before, it has been obliged to yield a coördinate position to kinetic theory in the presentation of the subject. There is evidence also that quantum theory will in the near future demand a front-line position. Historically, the principles of kinetic theory were developed not so long after those of thermodynamics had been established, but there has been a much greater time lag in the introduction of the principles of kinetic theory into physical chemistry than was the case for thermodynamics.

The retarded development which kinetic theory experienced in the growth of physical chemistry can be traced to the violent attacks made upon it by Wilhelm Ostwald and his school of energetics which dominated physical chemistry up to 1908. In the period from 1890 to 1908, thermodynamics definitely established itself as a very useful tool for both the physicist and the chemist. As Leonard Loeb has put it:

> At that time, perhaps somewhat as with relativity today, physicists sought to solve all problems of the universe by thermodynamics. Now thermodynamical reasoning does not require a knowledge of the precise mechanism of a reaction for its applications. All that is required is a complete knowledge of the work and thermal relations of a cycle of operations. Ostwald accordingly argued that given the thermodynamical treatment of a process one knew all that there was essential to be known about the process and that further mechanical assumptions as to the mechanism of the reactions were gratuitous hypotheses. He was correct in asserting that the mechanical assumptions of the kinetic theory were unproved hypotheses, but was wrong in urging that the rather sterile thermodynamical reasoning could be employed entirely to the exclusion of the neat and stimulating analysis of the kinetic theory, for, strangely enough, science progresses chiefly by mechanical analogies of nature's processes which occur to the mind of the investigator. The kinetic theory is just such a mechanical analogy. In fact, it seems to be the very fallibility of mechanical pictures which makes experimental test imperative and hence leads to further investigations and clearer knowledge. Science cannot progress entirely through the manipulations of equations indicating only the heat and energy transfers in the reaction, for such manipulations do not generally suggest further experiments. Fortunately, these attacks were brought to an abrupt end through the brilliant experiments of Perrin in 1908. Perrin conclusively demonstrated the existence of the continual heat motions of the molecules of a liquid by a study of the Brownian movements of suspended particles. These proofs were of such a definite nature that Ostwald accepted them and relinquished his exclusive claims for energetics.

At this point physical chemistry began a new era in which the electron as well as the atom and the molecule were to play the important rôle.

I do not wish to be understood as desirous of minimizing the place or the value of thermodynamics in physical chemistry; I am simply pleading that equal recognition be given kinetic pictures in presenting the subject. If each topic in physical chemistry is developed not only from the em-

pirical and thermodynamic viewpoint but from the kinetic viewpoint as well, then it becomes the duty of the teacher to keep the student fully informed at all times of the less certain and less definite character of the results of kinetic theory until they have been checked up by thermodynamics. The brilliant results obtained from kinetic theory as applied to gases is likely to lead the immature student to believe that kinetic theory is infallible, which is far from being the case with the methods at his disposal.

There is perhaps no better place to point out the limitations of classical kinetic theory than in a consideration of the specific heats of solids at low temperatures. Here the classical law of equipartition which has served so well for gases breaks down completely and the need of an extension of classical mechanics in molecular processes is brought forcibly to the foreground. Einstein's and later Debye's explanation of the temperature variation of the specific heat of solids was one of the first triumphs of the quantum theory, and it furnishes an excellent opportunity to acquaint the student with one of the most useful results of that theory.

If we continue our inventory of topics that should be presented in physical chemistry today we find that an adequate treatment of the solid state also demands that some time be devoted to the important results of the x-ray analysis of crystals, and the same holds true for the subject of photochemistry and the interpretation of the periodic law in terms of atomic structure. In the field of liquids a discussion of electric di-pole moments and of the orientation of molecules at interfaces is now compulsory if one is to delve at all into the question of surface tension and modern views upon heterogeneous catalysis. All of these topics are essentially products of investigations published within the past decade.

How are we going to accommodate these newer developments in a course which is already crowded with material, particularly when we also recognize that for an adequate treatment of these topics more time must be devoted to reviewing those phases of mathematics which are absolutely necessary to the presentation but which the student has forgotten since his course in calculus?

The writer believes that the only way the modern developments of physical chemistry can be given in the time usually allotted to the course is to enlist the coöperation of the teachers in the previous courses in general and analytical chemistry. In many of the larger universities a year is now being devoted to the subject of general chemistry. The students entering the course in general chemistry have had a previous course in high-school chemistry or its equivalent in the form of an introductory college course, the chief purpose of which is to acquaint the student with the materials of chemistry and to interest him in the subject. At Columbia we are working out a scheme whereby the students taking general

chemistry are divided into two groups: namely, (*a*) those who wish a year of chemistry for cultural purposes, and (*b*) those who expect to continue in chemistry as a subject of major interest. It is for this latter group that I am now concerned. As Hugh Scott Taylor has expressed it:

> Anyone who has examined the scope of the present day course in general chemistry cannot but be struck with the very considerable amount of physical chemistry which finds its place in such a course, often to the detriment of the purely inorganic chemistry. The physical chemistry is of course largely descriptive but it is substantially similar in form of presentation to that given a decade or so ago.

I agree with Taylor that physical chemistry ought to reap the advantages of the development in general chemistry by substituting a more rigorous and more mathematical discipline in the course of physical chemistry.

The large amount of time and space which has usually been devoted to the development of dilute solutions, and particularly the ramifications to which the conductivity aspects of this subject lead, seem out of keeping with their practical importance. This is especially true now that the trend in the teaching of analytical chemistry is to usurp such topics as solubility product, complex ion formation, concentration cells, electrometric titration, and their applications to oxidation-reduction reactions. The writer is entirely in sympathy with this movement and feels that physical chemistry is now in a position to relinquish its hold upon the teaching of these topics in favor of analytical chemistry, "without losing any of its thunder." This arrangement permits the physical chemist to proceed to subjects more in the nature of pioneering, for after all the physical chemist must be the pioneer as regards the introduction of both theoretical and experimental methods.

The objection may be raised as to the advisability of introducing so many of the principles of physical chemistry, in their more elementary form into the course in analytical chemistry. The argument is advanced that the older analytical chemists had little theory to guide them; they discovered the facts by experiment without knowing or caring particularly about the theory involved. As I see it the answer to this objection is that the increase in the speed and accuracy of modern quantitative analysis has almost always been the result of a careful study of the principles involved. In the old days the analytical chemist selected the indicator suitable for a given titration by trial and error and, we may add, by a certain amount of intuition and good fortune. Today, by applying the principles of physical chemistry, he can predict the proper indicator to use, provided only that he knows the mass action constants for the acid or base being titrated. The recent work of MacInnes and his collaborators in the field of precise differential titrations furnishes a good example of what can be accomplished.

If analytical chemistry is to develop and become something more than a technic, then the privilege must be granted the teacher of analytical chemistry to present these topics of classical physical chemistry which he needs and in a manner as best fits his course.

I hope that the discussion which follows will not be restricted to the past and present phases of the teaching of physical chemistry, but will attempt to give us an insight into what future developments may be expected. Dealing in futures may be thought to be solely the province of the research worker on the grounds that the teacher cannot be held responsible for subject matter which has not yet come into existence. This may be true enough as far as it goes, but the job of the teacher is hardly completed when he presents only the present and past achievements of his subject and trains the students in the application of the principles involved. He ought also to select some of his subject matter so that five years hence his students will be prepared to recognize new advances when they appear and be in a position to grasp their significance even if they cannot follow the new methods in detail.

The writer believes that statistical mechanics is most likely to furnish the theoretical tools needed for the future development of physical chemistry. A detailed treatment of statistical mechanics is, of course, out of place except in an advanced course in physical chemistry, because of the heavy mathematical requirements.

However, it is possible to give a survey of the methods employed without dwelling in too much detail upon the mathematical transformations. In the text book by Eucken,[2] translated by E. R. Jette and the writer, a brief presentation of the foundations for this subject and its application to elementary quantum theory are given on pages 64–74 and 105–126. The graduate student of physical chemistry should also be able to recognize the relation of Boltzmann's equation to the thermodynamic formulas which he is using and at least enough about statistical mechanics not to confuse phase space with the phase rule. Rodebush, writing on the Third Law of Thermodynamics in Vol. II of Taylor's "Treatise of Physical Chemistry" (pp. 1167–1180) has given an excellent account of the fundamental concepts necessary for prosecuting advanced work in this field.

The phenomenal success which the Debye-Hückel theory of electrolytes has had in clearing up the long-standing problem of the anomaly of strong electrolytes is adequate evidence of the necessity of presenting the elementary concepts of statistical mechanics in physical chemistry, if any real progress is to be made in this field. In this case the Poisson-Boltzmann equation is introduced as a beautiful short cut for the complicated Gibb's phase integral. It appears that the method of statistical mechanics

[2] Eucken, Jette, and LaMer, "Fundamentals of Physical Chemistry," McGraw-Hill, New York City, 1926.

furnishes the only safe procedure in arriving at a correct theoretical equation of state for matter in any state of aggregation. Further familiar contributions of statistical mechanics may be cited.

For example, the prediction of a chemical equilibrium in the absence of measurements on the equilibrium state itself requires a knowledge of the numerical values of the integration constant resulting from the integration of the Gibbs-Helmholtz equation. Classical thermodynamics is powerless to answer this question, yet statistical mechanics through the Sackur-Tetrode equation furnishes an exact answer to this problem as far as monatomic gases are concerned. In the case of polyatomic gases the results are not as clear cut, but sufficient progress has been made to get some very helpful results.

If our knowledge of the equilibrium state is reaching a satisfactory condition, we unfortunately cannot say as much for the equally important problem of reaction velocity. We know the ratio of the two component velocity constants must equal the value of the equilibrium constant, but of the factors which contribute to the absolute value of the velocity of each component reaction we know very little. The methods of classical physical chemistry again seem to be powerless to unravel the mysteries of reaction velocity but if the present progress in atomic physics along the lines of predicting the frequency of the transitions in the subatomic energy levels continues—processes which are really nothing more than the simplest of chemical reactions—we ought to see much progress in the near future. Statistical mechanics makes the bold attempt to predict the behavior of the crowd on the basis of laws found valid for macroscopic bodies, and as such is a fundamental science which ought eventually to yield the key to the problem of reaction velocity.

Plant-Poisoning Compound in Walnut Tree Identified. Penta-hydroxy-alpha-naphtha-quinone. That is the exact name, outlining for the understanding of organic chemists the exact structure of the stuff in walnut trees that keeps the ground under them bare of plant life. The tracing of this walnut poison to its chemical lair was described recently before the physiological section of the Botanical Society of America by Everett F. Davis of the Virginia Agricultural Experiment Station.

The antagonism of walnut trees to other forms of plant life has long been noted by farmers as well as botanists. It was supposed that the trees poisoned the other plants, but nothing was really known of the nature of the substance until the Virginia researcher extracted and purified it. Having got the natural substance, he proceeded, after the manner of organic chemists, to make a synthetic duplicate of it. This artificial product proved to be just as poisonous to plants as its natural prototype.

Because the full descriptive chemical name is a bit cumbersome, Mr. Davis sought a shorter one for common use. The botanical name for the walnut is Juglans, so he called the newly discovered chemical "juglone."—*Science Service*

PHYSICAL CHEMISTRY AT THE PENNSYLVANIA STATE COLLEGE*

WHEELER P. DAVEY AND MARTIN W. LISSE, THE PENNSYLVANIA STATE COLLEGE, STATE COLLEGE, PENNSYLVANIA

The catalog of The Pennsylvania State College lists as physical chemistry all courses which "involve both physics and chemistry or which lie on the border line between these subjects." The broad definition of the subject implied in these words seems to be both logical and workable. It emphasizes the essential unity of chemistry and physics and is in accord with the trend in both these subjects. The spirit of this definition carries through both the undergraduate and the graduate work. The result is that physical chemistry is primarily regarded as a jointly owned project of the physics, chemistry, and biochemistry departments. Graduate courses which contain a great deal of physics and some chemistry (such as atomic structure and spectroscopy) are taught as physical chemistry by the appropriate members of the physics department. Other graduate courses (such as catalysis) are taught as physical chemistry by members of the chemistry department who do no undergraduate teaching in physical chemistry. Still other graduate courses (such as x-rays, crystal structure, and colloids) are taught by those who give undergraduate instruction only in physical chemistry. Still other graduate courses (such as the physical chemistry of the cell) are given by members of the biochemistry department. In this way the joint control of the work by the physics and chemistry groups is emphasized without neglecting the "physical chemists."

Much the same situation exists in the undergraduate work. Lectures in classes in which the subject matter has a distinctly physical trend are given by members of the physics staff. Members of the chemistry staff give the lectures in classes in which the subject matter is predominantly chemical. Courses which emphasize strongly both the physical and the chemical viewpoints are taught by specialists whose training and experience has been in both subjects. In addition, two undergraduate courses in elementary physical chemistry are offered by the department of biochemistry which, for various reasons, is attached to the School of Agriculture rather than to the School of Chemistry and Physics. The will to coöperate is, however, so strong between those teaching physical chemistry in the two schools that little or no inconvenience seems to result.[1]

The problems of undergraduate instruction in physical chemistry at The

* Contribution to the symposium on "The Teaching of Physical Chemistry," held by Divisions of Physical and Inorganic Chemistry and Chemical Education, at the 76th Meeting of the A. C. S., September 11, 1928, at Swampscott, Mass.

[1] For convenience in administration, the physical chemistry work of our School of Chemistry and Physics is listed as a division of the chemistry department.

Pennsylvania State College are rather unusual. Because of the probability that similar problems will come up in other colleges, it seems worthwhile to state in detail what these problems are and how they are being met. Four widely different types of undergraduate students are required to take courses in physical chemistry. These may be classified as follows:

(*a*) Students with weak mathematical training who are not required to take either physics or chemistry *as such* in their curriculum and whose life-work will probably not require a technical course in either science.

(*b*) Students with weak mathematical training who are required to take elementary courses in both physics and chemistry and who need elementary physical chemistry as part of their training.

(*c*) Students with at least one year of college physics, one and one-half years of college chemistry, and mathematics through calculus; whose major subject in college requires a good usable knowledge of at least a portion of physical chemistry.

(*d*) Students specializing in physics or chemistry. These men are required to take mathematics through differential equations.

These four groups present four different problems, not only because of their widely different preparation, but also because of their different viewpoints. It is not claimed that we, at Penn State, have found the best possible solution to the problem, but we believe we have at least a workable solution.

Group (*a*)—Certain of our college curricula, such as Arts and Letters, Commerce and Finance, and Education do not include even the elementary college courses in chemistry and physics. Most students in the curriculum in Education have no mathematics beyond what they had in high school and this does not have to exceed algebra up to quadratics and plane geometry. Students in the curricula of Arts and Letters and of Commerce and Finance are required as part of their general cultural training to take throughout the freshmen year a "survey course" in mathematics which covers in three hours per week the elements of algebra, trigonometry, analytic geometry, and calculus. All of these students are required by their respective schools to take also a one-year survey course involving both physics and chemistry as part of their cultural training. By definition, such a course, combining as it does simultaneous instruction in both physics and chemistry, is listed as physical chemistry. Those lectures which emphasize the physical side of the picture are given by a member of the physics staff; those which emphasize the chemical side are given by a member of the chemistry staff. By close coöperation of the two the lectures make a homogeneous whole. Demonstration experiments are carried on throughout the lectures, not by way of illustrating laws and rules given *ex cathedra* to the class by the lecturer, but rather as a means of providing definite facts on which to base a discussion from which the class discovers

for itself the laws involved. This is one of the most popular courses in the college. It has about 460 students.

Group (*b*)—Students in the pre-medical and biochemical curricula are required to take the usual elementary courses in physics, and in inorganic, analytical, and organic chemistry. It is almost self-evident that these students need a good working knowledge of physical chemistry. Although they have mathematics through trigonometry, their whole mental bias is inclined to be non-mathematical. It is easy to say: "Put more mathematics in their curriculum," but it is hard to find the necessary time. It is easy to condemn a student for not liking mathematics, but it does not follow that only mathematical enthusiasts have a rightful place in the world, even though that world is constantly becoming more and more mathematical.

We seem to have our choice of two ways of solving the problem of teaching these men physical chemistry. We can give them merely the qualitative material that passed for physical chemistry twenty years ago, or we can try to give them a word-picture of what higher mathematics is really like, and then use the language and notation of calculus (with constant reference to the word-picture) in the effort to show these students how we arrive at modern physico-chemical ideas. At The Pennsylvania State College we have adopted the second of these alternatives. It is important in this connection to note that those who teach physical chemistry in the School of Agriculture and those who teach it in the School of Chemistry and Physics have arrived at practically the same solution of the problem. A conference of teachers from both schools shows that the work offered by one differs from that offered by the other mainly in minor details. We feel that the close parallelism between the courses developed independently by the two Schools is a strong argument in favor of the correctness of our solution of the problem. It will be of interest to describe the two courses more in detail.

All juniors in group (*b*) are required to take a full year of physical chemistry. Premedical students are scheduled in the same lectures and laboratory sections as men from groups (*c*) and (*d*). They are taught by men in the department of chemistry who are specialists in physical chemistry. Students in biochemistry and in certain agricultural curricula are scheduled in separate courses which are taught by a specialist in the department of bio-chemistry. It is taken for granted in both courses that the subject cannot be taught without the use of mathematics, but there is a constant effort in both courses to keep the mathematics to a minimum consistent with a proper understanding of physical chemistry. Whenever there is a choice between an elegant mathematical derivation and a word picture of a physical idea, the word picture is used. If a mathematical discussion is necessary for a proper understanding of a given

topic, it is preceded by a qualitative word-picture, and the mathematical treatment is correlated step by step with the word picture. Although of necessity derivations of equations are given frequently in the lectures, every effort is made to keep from taking for granted any previous knowledge of mathematics. Even simple algebraic steps are explained in detail. This is in accord with the common experience that the average student does not carry over into one classroom all that he has learned in some other classroom. Nor is it to be expected that he will. If he knew enough about mathematics, physics, and chemistry to be able to correlate them himself during a lecture in physical chemistry, he would already know so much physical chemistry that he would not need to take the course. It is a common mistake in teaching to assume that correlations which are almost self-evident to the teacher will occur at all to the unaided student.

Not only are the bio-chemistry and the chemistry departments in accord in their treatment of the mathematical side of elementary physical chemistry, but they are in substantial agreement as to what topics should be included and what should be omitted from an elementary course. The courses given by both departments include most of the standard topics to be found in the index of any recognized elementary text except that thermodynamics is omitted entirely. It is our feeling that the study of physical chemistry from the thermodynamic standpoint should be put off until the student has had a chance to find out what the subject matter of physical chemistry consists of. This topic is therefore postponed until the senior course mentioned under (*d*). Both departments agree also in the necessity for having the student work out numerous problems in connection with his elementary work. The chemistry department assigns about two hundred problems during the year. The biochemistry department assigns about 450 problems, some of which are non-mathematical.

The courses offered by the biochemistry and the chemistry departments for students in group *b* differ considerably in: (*1*) the order in which topics are taken up, (*2*) the illustrations cited for the various topics, (*3*) the reference books used, and (*4*) the amount of laboratory work required. These differences reflect partly the differences in personalities of the instructors (each feeling free to give his course in the way in which he feels he can do it best) and partly the previous training of the members of the class. They do not affect the general content of the two courses nor the basic aims which underlie them. The biochemistry department gives three lectures and one two-hour conference per week during the first semester on the general laws and theories of physical chemistry. This is followed in the second semester by two lectures and one three-hour laboratory period per week, covering the more specialized topics such as colloids, pH, buffers, potentiometry, surface tension, viscosity, electrophoresis, electroendosmose, membrane potential, electrometric titration,

kinetics of enzyme reactions, photochemistry, etc. Practically all the illustrations used in the lectures come from the fields of biology, biochemistry, and agriculture, since these are fields of primary interest to the students. Most of these illustrations are but rarely found in the textbooks in physical and physiological chemistry in common use. During the first semester Chapin's "Second Year College Chemistry" is used as a text, supplemented by frequent references to Findlay's "Physical Chemistry for Students of Medicine," and Philips' "Physical Chemistry; Its Bearing on Biology and Medicine." During the second semester the text is Kruyt's "Colloids" supplemented by Pauli's "Proteins," Loeb's "Proteins," Clayton's "Emulsions," Cowdry's "General Cytology" and Hoeber's "Physikalische Chemie der Zelle und Gewebe" (translated by the instructor and made available as a reference to the students in typewritten form). Required laboratory work is confined to three hours per week during the second semester. Additional laboratory work may be elected.

The chemistry department gives three lectures per week during the first semester and two lectures per week in the second semester. A three-hour laboratory period per week is given throughout the year. The lectures of the first semester include atomic structure theory, the three states of matter (with considerable emphasis on the crystal structure of solids), colloids and surface phenomena, osmosis. Those of the second semester include chemical equilibria, thermochemistry, chemical kinetics, theory of solutions, electrolytic conduction, electrolytic equilibrium, electromotive force, pH, photochemistry. Since the lectures are also attended by students in metallurgy, ceramics, geology, chemistry, chemical engineering, and physics, an effort is made to draw in illustrations of physico-chemical principles from all these fields. This means that the pre-medical students do not have a chance to get so many illustrations from the biological sciences as do those in the course given by the biochemistry department. This is to a large extent, however, offset by the breadth of information which they gain by hearing in the same lecture illustrations from their own field and from two or three other fields. It is the experience of the chemistry department that the premedical men are as interested in the properties of metals as deduced from crystal structure studies as they are in learning that crystal structure studies indicate a fundamental difference in the type of union between the atoms of an organic molecule (such as their drugs) and the atoms of most inorganic compounds (such as NaCl). They seem as interested in monomolecular oil films on water or on the metals of a bearing as in the monomolecular layer of the stabilizing agent of an emulsion. As in the case of the course given by the biochemistry department, the illustrations used in the course given by the chemistry department come from many sources. They cannot be found in any

one book, nor even in any ordinary collection of books. No regular text is used in connection with the lectures. The students are all required to use Getman's "Outlines of Theoretical Chemistry" because it contains so much material that they stand a good chance of finding in it the topic which they need to look up. No regular assignments are made in Getman, but whenever possible the statement is made in the lecture that the ground covered will be found in Chapter — of Getman. Premedical students are advised to use Bayliss' "General Physiology" as an additional reference. Knox's "Physico-Chemical Calculations" is required as a source of problems. The laboratory work, using Findlay's "Practical Physical Chemistry" as a text, consists of one three-hour period per week throughout the year. In addition to the text, mimeographed sheets are furnished for each experiment. These sheets are partly intended to fill the gap between the laboratory manual and the actual experiments which we assign, but they are also intended to give the student an idea of why he is asked to do that sort of experiment at all, and to show him the importance of that type of laboratory work in industry, medicine, or research.

Group (*c*).—This group includes juniors in metallurgy, ceramics, mining, geology, and electrochemistry. Although these men have all studied calculus they are, with few exceptions, distinctly non-mathematical in their general mental habits. All of these students come from other schools in the college and the amount of physical chemistry which they are required to take is prescribed by their own schools. For instance, metallurgists take all the lectures throughout the year but no laboratory work; ceramists take only the lectures of the first semester, so that they get no instruction in the theory of solutions, electro-chemistry, etc.; geologists and electrochemists are required to take both lectures and laboratory work during the first semester. These students all take their work along with the premedical men and with the juniors of group (*d*).

Group (*d*).—These men are all enrolled in the physics, chemistry, physical chemistry, or chemical engineering curricula. These students all have mathematics through calculus and most of them through differential equations. From the very nature of their work it is to be assumed that all of them have had considerable experience in using mathematics. During their junior year these men are all given the laboratory work and lectures already described for our pre-medical students under (*b*). This course serves to give them an idea of physical chemistry as a whole. It is the equivalent of the average undergraduate college course in the subject. We give as the aim of their junior course that, (*1*) the laboratory work is to give them a facility in making physico-chemical measurements without which they cannot hope to hold a job at all, and (*2*) the lectures and problems are to give them a knowledge of the theory without which they cannot hope to hold a worthwhile job.

The field of physical chemistry is already so large and is growing so rapidly that a student cannot learn in one year all that his prospective employer expects him to know. We have therefore scheduled a second year of work for our senior chemists, chemical engineers, physical chemists, and physicists. These men are already supposed to know from their work in the junior year what physical chemistry is about. They are supposed to have acquired a "feel" for the subject. They are now ready for a good stiff course which uses the junior course as a foundation, and which goes beyond the ordinary undergraduate work. During their senior year, therefore, they are required to cover the subject from the standpoint of thermodynamics. The course follows the general content and treatment of Noyes and Sherrill. The junior course has as its aim the student's immediate future; the senior course has as its aim the student's ultimate advancement.

The junior and senior courses not only give a good training for the student who must leave the university at the end of his senior year, but they also serve as a good foundation for his more fortunate brother who goes on to graduate work. The senior course goes beyond the undergraduate training in most universities. For this reason it carries graduate credit for the benefit of men coming to our Graduate School from other institutions. During the past year, one-third of the men taking our senior course were graduate students. They represented undergraduate work done in thirteen first-class colleges and universities. So far, not one of our graduate students from other institutions has had, as an undergraduate, the equivalent of the course described above. This may leave us open to the accusation of forcing our undergraduates too far. But we have to remember that each year, as our knowledge of physical chemistry grows, industry demands a better trained raw-recruit than the year before.

Such a course leads naturally to a general mathematical graduate course which covers in one year the equivalent of Taylor's two volumes, except that somewhat more attention is given to the mathematics of the Debye-Hückel theory of solutions of electrolytes. The course might well be called "The application of physics and mathematics to chemical problems." It is one of the aims of the course to help the students overcome the natural fear which any normal human being has of a page full of equations and to train them to read such a page easily with the aid of a pencil and a piece of paper. In this way we try to prepare them for a time, possibly ten or fifteen years hence, when by reason of changing conditions, the ability to read a mathematical article in physical chemistry will be a prerequisite to advancement in their chosen profession. For graduate students who present physical chemistry as their major subject the general mathematical course is followed by specialized courses in x-rays and crystal structure, colloids, catalysis, phase rule, atomic theory, spectroscopy,

microchemistry, etc. For graduate students in bio-physical chemistry the department of biochemistry offers additional courses in physical chemistry of the cell and in bio-physical measurements. These courses not only lead to advanced degrees in bio-physical chemistry when supplemented by physical chemistry courses offered by the chemistry department and by additional work in mathematics, but they also serve to give physico-chemical training to graduate students in agriculture.

We do not wish to take the ground that the solution given above to the problem of teaching physical chemistry is the only possible solution, or even that it is the best possible solution. We do feel that it is a workable solution which apparently fits our peculiar conditions. We have outlined our solution rather completely in the hope that it may be of value to other institutions which have equally complex problems. It is inevitable that the men we graduate this year will some day have to compete with younger and still more highly trained men. This implies that any proper solution of the problem of teaching physical chemistry must take into account the obligation to give our students such a training in mathematics and science that this year's class can fill for itself, by home study, the gap between physical and bio-physical chemistry as we know it today, and the physical and bio-physical chemistry that will be fifteen years from now.

Interne System Urged in General Education. The present scheme of compressing education into a few of the earliest years and of stopping it abruptly at some year in the teens was challenged recently in an address by Dr. A. I. Gates, of Teachers College, Columbia University, before educators attending the meeting of the American Association for the Advancement of Science in New York.

"The old notion that the teens comprise the prime of life for learning has been definitely disproved," Dr. Gates stated. "The decade from twenty to thirty is superior to any other."

To secure the advantages of education in the valuable years of the late teens and early twenties, and to make schooling more useful by relating it directly to the needs of practical life, he advocated a gradual transition from the life of school to life in the world. This method is already used and found satisfactory in medical training, where young doctors serve an interneship, and Dr. Gates recommended that young people being trained to carry on the world's work and soon to take civic and social responsibilities should complete their education by a "social interneship."

Recent research has dealt a blow to the old tradition that highly abstract subjects such as Latin, mathematics, and physical science are useful because of their disciplinary value to the mind, the speaker said. Prof. E. L. Thorndike has shown, Dr. Gates declared, that these subjects excel very slightly, if at all, such subjects as civics or biology or even stenography, manual arts, or cooking as means of increasing the student's general ability to think.—*Science Service*

PHYSICAL CHEMISTRY FOR PREMEDICAL STUDENTS*

EARL C. H. DAVIES, WEST VIRGINIA UNIVERSITY, MORGANTOWN, WEST VIRGINIA

A survey of available catalogs for about seventy of the Medical Colleges of the United States, Canada, and other countries is but mildly encouraging to those physical chemists who believe that an elementary knowledge of the subject is essential for future physicians. It appears that physical chemistry is not only not required but that it is rarely even being suggested as a possible elective.

In the *University of Chicago* catalog we read:

> In a calling which is as multiform as is the practice of medicine, rigidity of curriculum is impracticable.

Indiana University says:

> While most applicants for matriculation have work in excess of the minimum, students should not make the mistake of thinking their eligibility for matriculation is increased by doing one or two additional years' work of low grade. Preference is given to students with two years of collegiate work completed in a qualitatively superior way rather than to students with four years of collegiate work of low grade.

The attitude of many Universities is typified by the terse statement of the *University of Oklahoma:*

> Member of American Association of Medical Colleges and conforms strictly to the rules and requirements of that organization.

Perhaps catalogs do not, on the surface, reveal the real conditions. In private conversation, members of the boards who pass upon premedical students, emphasize that there is a wide chasm between the published minimum and the real training necessary for actual admission. But even so, these boards feel bound by the admission requirements of the American Association of Medical Colleges and the Association does not require physical chemistry.

At present the Medical Colleges are trying to get intelligent, able chaps with high grades rather than those who may have had this or that particular course, and we must admit that many otherwise excellent men do not study physical chemistry, while there are others who know a lot about osmosis and pH values, and yet them we would not trust to give us a dose of citrate of magnesia.

Turning toward the future one can catch glimpses of progress. The *University of Louisville* says:

* Contribution to the symposium on "The Teaching of Physical Chemistry," held by Divisions of Physical and Inorganic Chemistry and Chemical Education, at the 76th Meeting of the A. C. S., September 11, 1928, at Swampscott, Mass.

The least desirable preparation for the study of medicine is comprised in the scant minimum requirements without which no Class *A* medical school may admit students and retain its Association rating. Students who rely upon such minimum preparation usually find themselves at a disadvantage beside better prepared students in a medical school.

Vanderbilt University says:

It is recommended that the study of chemistry be extended when possible to include an introductory course in physical chemistry.

Washington University (St. Louis) says:

A course in elementary physical chemistry is strongly recommended.

The *University of Alabama* says:

The American Medical Association strongly advises that physical chemistry be included in premedical preparation.

West Virginia University may be taken as an illustration of the rather definite requirement of physical chemistry for the two-year premedical students.

Curriculum Leading to the Degree of Bachelor of Science in Medicine at West Virginia University

In the following schedule the premedical course offered at this University is shown. The courses marked with a star are the minimum requirement of the Association of American Medical Colleges. Those not marked are the additional courses required by this University for the B.S. degree in Medicine and must be met before a student will be admitted to the second year of the medical course.

Courses in the Colleges of Arts and Sciences

First Year—First Semester		*First Year—Second Semester*	
*English 1	3	*English 2	3
English 3	2	English 4	2
*Chemistry 1 (Inorganic)	4	*Chemistry 2 (Inorganic)	4
*Zoology 1	4	*Zoölogy 2	4
German or French[1]	3	German or French[1]	3
Military Science	1	Military Science	1
	17		17
*Physics 1	3	*Physics 3	3
*Physics 2	1	*Physics 4	1
Chemistry 15 (Quantitative)	3	Philosophy	3
Elective (Phy. Chem. Lab., 1 hr.)	5	*Chemistry 36 (Organic)	5
Chemistry 63 (Physical Chem.)	2	Elective	2
Military Science	1	Military Science	1
	15		15

[1] Six hours of a modern foreign language are required if two years' work in the language are offered for entrance credit, otherwise ten hours of college work in the language are required.

The schedule allows 7 semester hours for electives in the sophomore year. Two hours of physical chemistry are required during this year, while about 85% of the students take an additional 1 hour of laboratory as elective. The other 6 hours of electives frequently include a 4-hour course in comparative anatomy and a 2-hour course in German or French. Besides this group of students we have a growing number who complete 3 or 4 years of college work before entering medicine. These 3- and 4-year students generally "major" in chemistry and, among other things, they take 4 to 8 hours of physical chemistry, often followed by a 4-hour course on the chemistry of colloids.

It might be ideal if all premedical students could take from 5 to 10 hours of physical chemistry. But the fact is that even a 2- or 3-hour course is an unusual requirement. In such a short course it is not possible to adequately cover all the topics which will be most useful for the future physician. The author has been using his own mimeographed text which includes both the theory and also laboratory and lecture experiments. Special emphasis has been placed upon osmosis, atomic structure, radioactivity, pH, and colloids. During the past year it has been corrected, enlarged, and rearranged.

Many people feel that premedical students should not be in a separate class and there are some good arguments against segregation. But at present it is not so much a question of what physical chemistry shall be taught to premedical students as it is whether any shall be taught. It is not so much a question of whether the premedical student should have his own special course but should he have any course. At some of our colleges it may never be possible or profitable to segregate premedical students, but at least the teacher will know which of his pupils do expect to become physicians and he will want to see that these students excel in those topics which are more essential for medicine. In the larger universities segregation of premedical students is no hardship. In our own case at West Virginia University we have around 30 in the regular course of physical chemistry while there are about 90 in the premedical work or a ratio of about 3 to 1 in favor of the latter. In such cases it is obviously easy and natural to segregate.

Finally, it would seem that all signs point to the probability that physical chemistry will somehow be taught to our future physicians. If teachers of this subject do not themselves respond to the need, then the physical chemistry will be sandwiched into courses in general chemistry, analytical chemistry, organic chemistry, and in physiological chemistry. If we believe that physical chemistry is something definite, tangible, a branch worthy of its own individual recognition, then we must keep awake to the needs of the medical profession. Those of us who spend our lives on this branch well know that it is so big and so intricate that no one man has

time or energy to follow all its many ramifications. How, then, can one hope that the teachers of general chemistry, organic, or physiological chemistry will be able or willing to take time and energy to adequately present the physical chemistry needed by their students?

If physical chemistry were required of all premedical students in America, it would mean more than a doubling of the present enrolment in this subject. The premedical student would simply be substituting the 2 or 3 hours of physical chemistry for some of his present electives. Each of us knows of some of these electives, typified by certain foreign students who elect to continue the study of their mother tongue not because they learn anything new but because they need the hours. Perhaps some of us may now or in the future have the opportunity to help revamp the requirements of the American Association of Medical Colleges. If so, is it too much to hope that physical chemistry may be given a place among the definite requirements of premedical students? In the meantime each one can, in his own college, direct attention to the fact that there is a branch of chemistry known as physical chemistry and that its study will be profitable to anyone who expects to become a physician.

UNITED STATES CIVIL-SERVICE EXAMINATION

The United States Civil-Service Commission announces an open competitive examination for Junior Patent Examiner, at an entrance salary of $2000 per year. The examination is to fill vacancies in the Patent Office, Washington, D. C.

Applications must be on file with the Civil-Service Commission at Washington, D. C., not later than March 5th.

The duties are to perform elementary scientific or technical work in the examination of applications for patents; to see what the alleged inventor thinks he has produced that is new; and to see that the disclosure is complete; and to investigate the prior art as represented by patents already granted in the United States and various foreign countries and by the descriptions in technical literature.

Competitors will be rated on physics, technics, mechanical drawings, and the optional subject or subjects chosen. The optionals are (1) mechanical engineering, (2) physical and organic chemistry, (3) chemical engineering, (4) civil engineering, (5) electrical engineering. French or German, or both, may also be included if desired. Qualifying in the language test increases the probability of appointment.

Full information may be obtained from the United States Civil-Service Commission, Washington, D. C., or from the secretary of the United States Civil-Service Board of Examiners at the post office or customhouse in any city.

Heavy Aluminum Kettles No Better than Thin. Heavy aluminum cooking utensils are shown to be no more efficient than less expensive lighter weight kettles, as the result of careful experiments by Catherine Landreth of Dunedin, New Zealand, research specialist in home economics now working at the University of Washington.—*Science Service*

THE TEACHING OF ATOMIC STRUCTURE TO PHYSICAL CHEMISTS: ROUND-TABLE DISCUSSION*

H. C. UREY, THE JOHNS HOPKINS UNIVERSITY, BALTIMORE, MARYLAND

During the past four years I have been teaching atomic and molecular structure to graduate students of chemistry and with rather indifferent success. Today, I do not have any very certain views on the subject. Many times I believe that the future of chemistry is entirely technical and that physicists will gradually absorb all physical chemistry of purely scientific interest. Yet this may not be true and, being a chemist very much interested in the structure of atoms and molecules, I would like to see physical chemists have some of the fun in the revolutional developments in this subject.

There is no doubt that chemists entering our graduate schools do not know any mechanics worth mentioning and it is completely useless to talk about teaching wave or matrix mechanics to people who do not know any classical mechanics, no matter how desirable that would be. However, there is no limit to the amount of this sort of work which the Ph.D. candidate can take with profit. Let us not make the mistake of putting any limit on the profitable theoretical training of the pure scientist as has been done in the past with respect to mathematical training. I believe that we must either attempt to bridge the gap between the classical training of a chemist and that of the physicist or else admit that we and our science will take the same position relative to physicists and physics that engineers and their subjects now hold relative to the latter.

But I shall return more nearly to the subject of this discussion. The last time I gave a course on this subject we spent about six weeks on mechanics before taking up the subject of atoms and molecules at all. This course was much more successful than the preceding ones in which this preliminary view of mechanics was not given, and I found it possible to give much of the experimental facts in detail. Emphasis should be placed on the experimental side for it is here rather than in theory that chemists can contribute more effectively to the subject.

One of the most effective methods of teaching this subject is in seminars. I have found in giving a lecture course that the lecturer works very hard, but the students do nothing at all. The lazy method of sitting back and letting the students give reports on papers and subjects is the quickest way of getting a group of students working on the subject and they learn far more. During the last year such a study group at Hopkins went over the work of Franck and his co-workers on the effect of light in dissociating

* Contribution to the symposium on "The Teaching of Physical Chemistry," held by the Divisions of Physical and Inorganic Chemistry and Chemical Education, at the 76th Meeting of the A. C. S., September 11, 1928, at Swampscott, Mass.

molecules and related topics with great profit. During the year 1928–29, we are going to take up the study of band spectra in much the same way and I believe that we will succeed in giving a great many of the experimental facts to our graduate students of chemistry. Such study groups can be organized by men who are not specialists in the subject with much profit to both students and faculty.

John Dalton and the Atomic Theory. The following quotation from *Memoirs of John Dalton and History of Atomic Theory Up to His Time,* by Robert Angus Smith (pp. 244–5), has been called to our attention by one of our readers with the comment that it "seems pertinent in view of the widespread belief that the newer findings relative to atomic structure are threatening our fundamental theories of chemical action.

"We have, in fact, found no name representing the case as well as atom, and, giving due limits to the meaning of the word, it represents the state of belief in the mind of every chemist, whilst no fact whatever bears directly against it.

"At the same time I do not mean to advocate the atom with the physical constitution given to it by Dalton, as well as by Newton and the ancients, not being able to see it possible; but this is not a place for my own views: I have referred to what may be called the practical atom, or the smallest amount that unites.

"Is then chemistry scientifically disposed of by this theory? As well might we say that Newton exhausted the heavens of its knowledge. Year after year will furnish us with marvelous truths, nor can we believe that centuries or millenaries will exhaust God's wisdom in the earth. The atomic theory may be further analyzed, and under its simple laws may be found another which will not only include all we now have, but a host of others still unsuspected; the time may even come when a new chemistry will be revealed to us, a world under our present elements, when every element will be convulsed and shaken into fragments by powers which nature will put into our hands; but even that does not destroy the laws of the present. Even when that scientific convulsion comes, we can scarcely doubt that the elements will break up, well proportioned and according to regular laws, if they break into fragments at all. But this stratum of our knowledge cannot be annihilated by any under stratum; what we have found is true, whatever higher truths may overpower us with their splendour. When these truths come let us receive them openly and willingly, giving them encouragement instead of envious repulsion, knowing, in fact, that they must come, and rather let us make an occasional mistake in harbouring a mere mortal, than lose the opportunity of an angel for a guest. There are incredulous fools who have made the world's throbbing heart a blank to them, lest they should perchance at times be cheated. There have been madmen who have refused to eat, lest they should be poisoned."

Potassium Shortage Hard on Cane Plants. Young sugar-cane plants take it hard when they do not get any potassium in their usual mineral ration, according to Dr. Constance E. Hartt of St. Lawrence University, who spoke recently before the American Society of Plant Physiologists. Plants started from cuttings in October and transplanted in November began to show symptoms of potassium starvation in March. These were decreased growth, dieback, and deficient development of the green coloring matter in the leaves. In some cases the action of vital processes was profoundly affected, as shown by changes in the enzyme activities.—*Science Service*

THE PROCESSES OF COLOR PHOTOGRAPHY. PART IV. THE KODACOLOR PROCESS

C. E. K. MEES, EASTMAN KODAK COMPANY, ROCHESTER, NEW YORK

In 1923 a new process of amateur cinematography was placed on the market by the Eastman Kodak Company. The process depended upon the use of a film 16 mm. wide instead of 35 mm., the width of standard motion picture film. This film, after exposure, is not developed to a negative and printed, as is customary with 35-mm. film, but is developed by what is known as the *reversal* process. In this reversal process, the exposed image is first developed, and then the developed silver is dissolved in a *bleaching* bath, as it is called, which oxidizes the silver. This leaves behind the silver bromide which was not affected by the developer because it was not exposed to light. After a fresh exposure to light, this remaining silver bromide is developed in its turn and gives a positive. This process is illustrated in Figure 23 which is a drawing made from pictures taken through the microscope. In section 1, we see the grains of the light-sensitive silver bromide in the emulsion, and in section 2 we have marked by crosshatching those which have been affected by light during exposure in the camera. They would not show any change to the eye, of course, because the change by light is not visible. The grains form what is called the *latent image*. Now, after development, these exposed grains turn into black metallic silver, and this is shown in section 3 of the diagram. Then, the bleaching bath removes all the silver, and it leaves behind the silver bromide grains which were not exposed in section 2. These are re-exposed and developed and make the final positive, as we see in section 5.

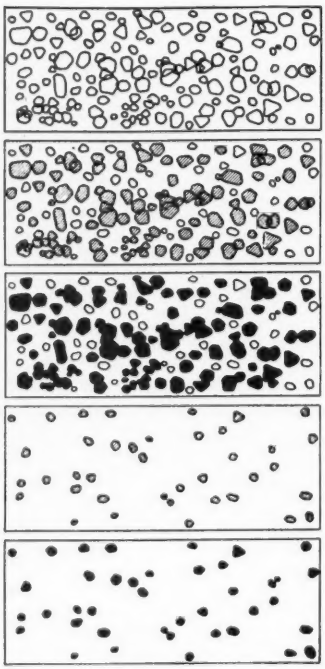

FIGURE 23

Since 1923, amateur cinematography has developed until now it is a considerable industry. The early apparatus has been supplemented by other forms of cameras and projectors, so that at the present time a wide range of extremely convenient apparatus made by several different manu-

facturers is available for the public. As a general rule, at the present time, the cameras are driven by spring motors which are wound between exposures, and the trend of design is in the direction of cameras as small and compact as possible, so that an amateur motion picture camera is little more bulky than the very small and compact cameras used for still photography.

In view of the success of this process of amateur cinematography, it is natural that the Kodak Company studied the various processes of color photography in order to find one which would be suitable for application to amateur cinematography. It was not easy to find such a process owing to the requirements which were considered necessary, one of which was that it should be possible for anybody without any special knowledge of the subject to take color pictures as easily as he could take monochrome pictures or still pictures in a kodak.

The most satisfactory process of amateur cinematography in colors would clearly be one depending upon the use of a screen film in which the film would carry the filter units preferably dispersed regularly in dots or lines. There are, however, great practical difficulties in the preparation of such a screen and in securing the adherence of the emulsion to it, which have hitherto prevented such a process from attaining practical realization.

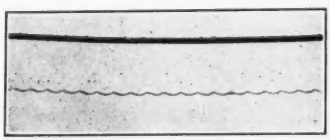

FIGURE 24

In 1908 R. Berthon patented a process which realized most of the advantages of a screen film process without involving too great difficulty in making the film. In this process the color filters are placed in the lens, while the film is embossed on the support side with a number of small lenses. In Figure 24 the corrugated edge represents the surface of the film base, in which the small lenses shown have been embossed. We see below this the thickness of the base itself and then a thick black line which represents the thickness of the emulsion. When this film is put into the camera, the embossed lenses will form miniature images of the diaphragm of the camera lens on the film emulsion. Suppose, for instance, that the lens contains a stop with three holes in it—one covered by a red filter; a second, by a green; and a third, by a blue filter. Then, behind each film lens there would be formed on the emulsion a group of three dots—one dot corresponding to the red filter; one, to the green; and the third, to the blue filter.

The effect produced by the embossed film and the filters in the lens is exactly similar to that which would be obtained by the use of a screen film in which the filter units were in contact with the emulsion, but the process has the advantage that the film is much easier to make and to use. The

lenses can be either spherical or cylindrical. If they are cylindrical, the filters used in the camera lens can be strips parallel to the embossing on the film, and we shall then get line images of them on the film.

Some years after this invention, Berthon became associated with Anthon Keller-Dorian, the owner of an engraving plant in Alsace, and the Société Keller Dorian-Berthon was formed to develop the process for commercial purposes. In 1925 this process was offered to the Eastman Kodak Company and was thought to offer possibilities of success, especially as it was closely akin in its requirements to the method of amateur cinematography which the company had already developed. Rights in the process were therefore purchased and development was started with a view to perfecting the process for use with the amateur 16-mm. film.

A great deal of study was involved. It was necessary to standardize the methods of making the lenses on the film; to design and make a suitable emulsion strongly sensitive to green and red light and yet with sufficiently fine grain for the minute structure of the separate color elements to be resolved; and, especially, to work out suitable methods by which the film could be developed and reversed while the rendering of color was retained. When all this work had been done, there was available a process which is simplicity itself from the user's point of view. In order to make the pictures, a photographer using a standard Ciné-Kodak fitted with an $f/1.9$ lens has only to insert a color filter into the lens and thread the Kodacolor film in the camera. After the film has been exposed, it is sent away for processing and comes back to the photographer as a roll of black and white film which can be projected in an ordinary projector and will give a black and white picture on the screen. But if the projector is fitted with a special color filter like that which is used in the camera, then a colored picture will be obtained on the screen.

The operation of the Kodacolor process is as follows. The color filter is composed of three separate areas—red, green, and blue—and slips into the front of the lens. The film is threaded into the camera with its back, that is, the side of the film opposite from the sensitive emulsion, facing the lens, so that the emulsion surface itself is away from the lens. The back of the film is embossed, by running through steel rollers, with tiny cylindrical lenses composed of the film base material and extending lengthwise of the film. The lenses on the film are about four times narrower than the dots making up the illustrations in a magazine, and they are therefore invisible except under a microscope. They cover completely the surface of the side of the film opposite from the sensitive emulsion.

When the trigger of the camera is pressed, light reflected from the subject passes selectively through the three-color filter, on through the camera lens, and thence through the tiny embossed lenses on the film to the sensitive emulsion coating on the opposite side, where it is recorded (see Figure

25). The function of the lenses embossed on the film is to guide the rays of light falling upon each tiny area and lay them on the sensitive emulsion as three distinct impressions corresponding to the three filter areas, so that the three colors covering the lens are imaged behind each tiny cylindrical lens as three parallel, vertical strips, because the tiny cylindrical lenses are parallel to the stripes of color on the filter. Thus, the width of each of the minute areas of emulsion is subdivided into three parts related to the three filter areas and affected by light that is able to pass through the different colors. The sum of these small affected areas of film constitutes the whole photographic image. A red ray from an object in front of the camera, for instance, reaches the sensitive film at a spot related to the red area of the filter. The *reversal process* turns this affected spot into a transparent area, leaving opaque the adjoining, unaffected areas related to the green and blue segments of the filter; so, also, with green and blue colors and with combinations of colors. The sum of the points on the scene containing red makes a photograph from red light on the emulsion areas related to the red filter area; the sum of the blue also makes a separate photograph; and similarly, the green.

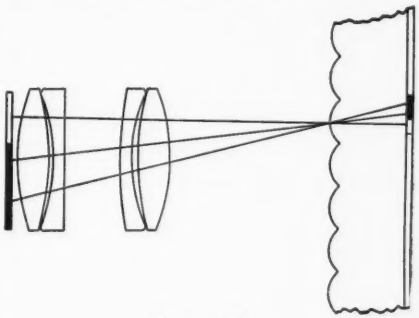

FIGURE 25

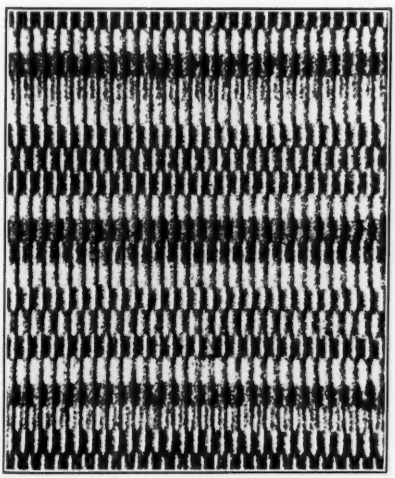

FIGURE 26.—Photomicrograph of Kodacolor Picture of Colored Bands.

In Figure 26 is shown a photomicrograph of a Kodacolor picture of a number of strips of colored paper, the strips being very narrow and photographed at some distance, so that a considerable number of different colors are included in the small section shown. It will be seen that the pattern is divided by dark, vertical lines, between each one of which the same pattern repeats. These vertical lines are the edges of the small film

lenses, and the pattern shown between each pair of lines shows the distribution between the red, green, and blue emulsion areas corresponding to each of the colored strips. Thus, in one strip it will be seen that two-thirds of the strip is clear and only one-third is darkened. This corresponds to a color such as yellow, for instance, in which only the blue area is darkened, the green and red being transparent.

In projection, the optical system of the camera is reversed. Behind the film are placed a condenser and a source of light. On the projection lens is a color filter of the same kind as that used on the camera lens and of the same three primary colors—red, green, and blue. When the picture is projected, the opaque areas of the film prevent the light from coming through the corresponding filter on the lens and thus falling upon the screen. For each color, therefore, the emulsion areas, whose density is determined by the exposure given in the camera and the subsequent reversal processing, regulate the amount of light transmitted through the red, green, and blue segments of the filter on the projecting lens and thus determine the color which is projected upon the screen; so that on the screen we obtain a reproduction of the original colors of the scene photographed.

Owing to the absorption of the light by the colors of the scene photographed in projection, it is necessary to be content with a small picture on the screen; so that with the highest power of tungsten light available, only small screens can be used, such as those which are suitable for use in the home.

In the camera, it is necessary to have some method of controlling the exposure for the three different colors. The film may vary somewhat in its sensitiveness to red, green, and blue. Even if a film be made which has even sensitiveness to the three different filters, it does not follow that this can be duplicated exactly, and on the exactness of adjustment depends the color rendering. The adjustment for the varying *sensitiveness* of the emulsions is accomplished by cutting down the length of the color filters used in the camera. This is done by what is termed a ratio diaphragm cap. After the emulsion has been tested, these caps are chosen to correspond to the color sensitiveness of that particular batch of emulsion, and the cap is then placed on the end of the film in such a position that it cannot be missed by the user. All that is necessary when placing a new film in the camera is for him to take his color filter out of the camera, and replace the ratio diaphragm cap by a new one from the end of the fresh film. In this way, he can always be sure of getting the correct ratio of exposures.

As will be realized, the projector system is optically an exact inversion of the camera system, but there is in general one difference between the camera and the projector: the focal length of the projection lens is usually made greater than that of the camera lens. The relative apertures must be the same; that is, the cone of light coming through the projector lens

must have exactly the same angle as the cone of light coming through the camera lens, since otherwise the optical conditions will not be reproduced correctly, and the colors will not be correct. A difference in focal length can, however, be compensated by the use of a supplementary lens, which places images of the color filters at the right point in the optical system; and this lens, which is termed a *compensator*, is fitted on to the lens of the projector. It makes no difference when black and white pictures are being projected except to change slightly the focal length of the projection lens, but it is necessary to obtain an even screen when Kodacolor pictures are being projected.

The results obtained with this Kodacolor process are of very good quality indeed, as would be expected from a three-color additive process. The process has, it will be observed, certain limitations.

As with a screen plate process, the small size of the separate units makes a considerable demand upon the resolving power of the emulsion, and a fine-grained emulsion is necessary, which is consequently limited in speed.

The pictures can be taken only at a very large aperture, approximately $f/2$, in full sunlight; that is, about three times as much light is required as is necessary for other processes of color cinematography employing filters but in which coarser grained and therefore faster emulsions can be utilized.

The preparation of duplicates or prints offers very considerable difficulties, and while some progress has been made in the preparation of these duplicates, especially for standard 35-mm. sized films, the process is not simple, and the ordinary manufacturing processes used in the making of standard motion pictures are not applicable.

In projection, there is a very serious loss of light caused by absorption of the filters, which always occurs in additive processes of color cinematography but is somewhat greater than that shown by other processes. The subtractive processes are free from this defect.

There are therefore a considerable number of difficulties to be overcome in the adaptation of Kodacolor to the production of color pictures for the motion picture theater, but its instantaneous success as an amateur process seems to show quite clearly that it has solved the problem of color motion pictures in the home.

Aspirin Declared Useless for Prolonging Life of Cut Flowers. That the common practice of putting an aspirin tablet into the water to make cut flowers last longer is without scientific basis, was indicated by the results of experiments reported before the physiological section of the Botanical Society of America, by A. E. Hitchcock and P. W. Zimmerman of the Boyce Thompson Institute for Plant Research. This compound and 43 other chemicals were tested with cut flowers of various species, while other vases of flowers were left with just plain water, as controls. In no case, the experimenters reported, did the chemicals increase the life of the flowers beyond that of the comparison specimens in pure water.—*Science Service*

CHEMICAL ENGINEERING BUILDING AT IOWA STATE COLLEGE

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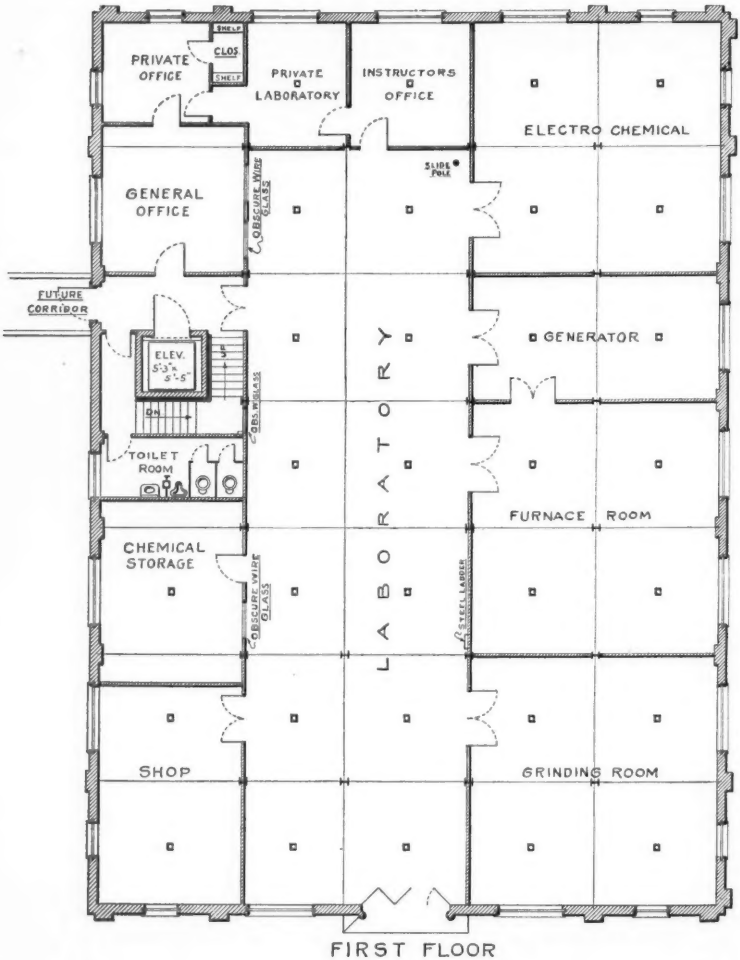
The new chemical engineering building at Iowa State College is attracting the attention of many college and industrial executives, largely because it represents one of a very few buildings designed especially for this class of work. This building is the outgrowth of the demands of the department for more effective housing necessary for its proper development. To understand the building, one must understand the policies and aims of the department. The Chemical Engineering Department at Iowa State College differs from many other such departments administratively by being an entirely separate department with separate faculty and separate policies. It is believed that chemical engineers worthy of the name cannot be trained merely as side issues by departments of chemistry or of mechanical engineering. This may perhaps be shown better by a consideration of just what constitutes chemical engineering and the chemical engineer. It may seem rather facetious to say that any sort of engineering is largely a state of mind. But the whole education of the engineer is built around the idea of attacking problems in the engineering manner, that is, with the engineering viewpoint or state of mind. The mechanical engineer attacks the problem from the mechanical standpoint, the electrical engineer from the electrical standpoint, and the chemical engineer from the chemical standpoint. To be sure the chemical engineer has developed a number of operations which, though more or less mechanical, he calls fundamental processes of chemical engineering. Not strictly chemical in themselves, they are processes which are necessary in large scale chemical work, just as are many mechanical operations of the chemist in his laboratory. But it is a far cry from the glass filter funnel of the chemist to the big rotary filter of the chemical engineer, or from the mortar and pestle to the modern crushing and grinding equipment. The design and operation of these tools of the chemical engineer are a separate science from that of the chemist or mechanical engineer, and must be taught as such. It is just as difficult to develop the chemical engineering viewpoint in the chemical laboratory by chemistry instructors as the mechanical engineer in the pure physics laboratory by physics instructors. This does not in any way imply that the chemistry training is not necessary to the chemical engineer. It is of fundamental importance, just as physics and mathematics are likewise of fundamental importance. At Iowa State College all of the pure chemistry in the chemical engineering course is taught by the chemistry faculty. This gives the student the advantage of training by specialists in the various branches of chemistry so that he is well grounded in the fundamentals on which to base his true chemical engineering training.

The laboratory apparatus and the experimental work of chemical engineering are such as to require a laboratory of different type from that used in pure chemistry work. Even the semi-commercial laboratory equipment often extends up heights greater than ordinary ceilings. It is frequently desirable to have two or more floors available for groups of equipment. The equipment is often very heavy, necessitating very strong floors. Heavy equipment must frequently be attached to walls and ceilings. Provision must be made for power and power transmission. Water and sewage pipes need to be large in size with large floor drains. Ample ventilation for the removal of disagreeable and harmful gases is required. All of these things were kept in mind in designing the new building.

Chemical Engineering Building, Iowa State College at Ames

The building is of steel frame construction with concrete floors and brick walls. The exterior brick is of pleasing red color which blends artistically with the white stone trim. The interior brick is of concrete. The latter not only blends well in color with the concrete floors and gray steel work, but because of its splendid acoustical properties is ideal for the well-like main laboratory. The H columns throughout the building have purposely been left uncovered so that they are available for attaching of equipment such as shafting. The main laboratory in the center of the building extends upward about thirty-five feet into a monitor. Surrounding the main laboratory is a mezzanine floor open into it on all but a portion of one side. This makes it possible to set up equipment on both floors with the desired

connecting pipes, conveyors, or other equipment. The roofs of both the main portion of the building and the monitor are flat so that it is possible to utilize them for equipment which can be set up outside. Not only does

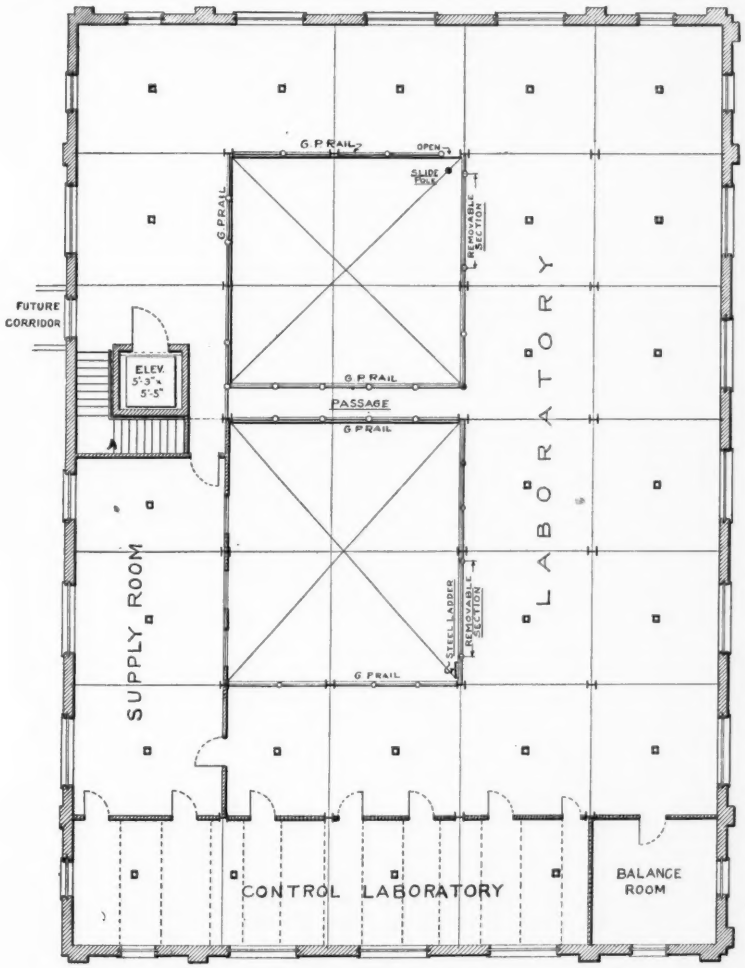


FIRST FLOOR

the monitor provide the extra height necessary for some equipment but makes possible through the numerous windows the removal of steam and noxious gases from the laboratory.

Another feature of the building is the provision for temporary set-ups of

equipment. The use of temporary set-ups is a part of the teaching policy of the department. There are, in general, two methods of teaching chemical engineering laboratory work. One method is to have a complete set or



SECOND FLOOR.

sets of equipment for the production of some chemical commodity or commodities. It in reality functions as a small scale factory operated by students. Excellent as this is in showing the detailed routine of a given indus-

try and the details of machinery for that industry, it is rather narrow in its scope and inclined to be rather more superficial than fundamental in its presentation of chemical engineering principles. The project method, on the other hand, is concerned with the carrying out of manufacturing projects involving the fundamental operations of chemical engineering. The operations carried out and studied are those fundamental to all chemical industries. They are the units which make up the completed whole of the final plant and are the basis of all chemical engineering operations. In following out this method it is frequently necessary and desirable for the students to make their own set-ups from equipment available. In

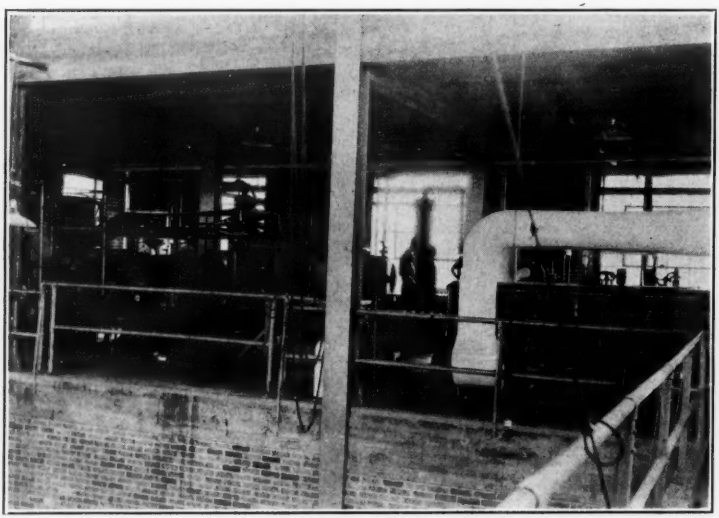


Photo Courtesy of U. S. Bureau of Standards

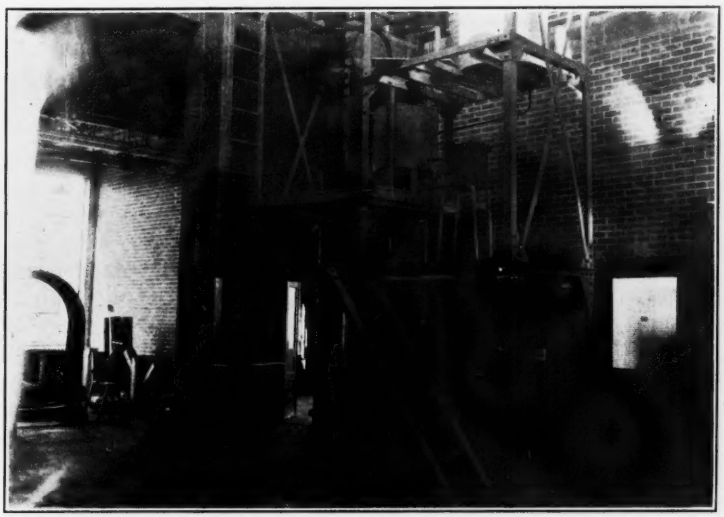
WALL BOARD MACHINERY

the carrying out of research projects, new equipment frequently must be constructed and put into operation. For these uses there are located on the various H columns which support the building groups of outlets so that there is available at each of these positions steam, electric power, gas, water, and compressed air. Portable electric motors and speed reducers in this way provide power at any part of the building.

At the west end of the second floor are located the laboratories for control and small scale research work. These are of rather unique construction. A long narrow room is divided by regulation chemical tables into a series of small laboratories each entered by a separate door. Gratings extending from the tops of the tables to the ceiling insure the privacy of

the laboratories. A balance room and a store room are located on this floor. The remainder of the space on the mezzanine floor is used for setting up laboratory equipment.

Surrounding the main laboratory and under the mezzanine floor are located the general office, office and private laboratory of the head of the department, office of the assistant professor, digester room, water softening laboratory, furnace room, grinding room, machine shop, and heavy chemical storeroom. A small basement is used for fermentation work. The laboratory equipment of the department includes such apparatus as single and double effect vacuum evaporators; vacuum dryer; centrifuges;



A TYPICAL SET-UP

various kettles and digesters; a glass-lined still and condenser; plate and frame, Kelley, and Sweetland filters; autoclaves; electric, gas, and oil-fired furnaces of various types; jaw, gyratory, and roll crushers; swing hammer mill; shredder; Hardinge mill with air separator; besides tanks, pumps, and other miscellaneous equipment.

But the function of the modern chemical engineering department does not end with the instruction of its students. This is particularly true in a state school where it is under obligation to be of service to the state. This obligation may be discharged in one of two ways: by research on subjects of particular interest to the citizens of the state or by direct consulting aid to the individuals and industries of the state. The scope and character

of this research and this consulting aid will vary with the state according to local needs.

One of the characteristics of the state of Iowa is the hardness of its water supply. Prior to the water softening work of the department which was begun in 1920, this hard water was costing the industrial users of the state an immense sum of money. Not only has extensive research work been carried on, but the staff of the department has given freely of its time in a consulting capacity on problems of this nature. It was only natural that a very well-equipped laboratory for research on water softening was built up. This laboratory, located on the first floor, is fitted up with several zeolitic water softeners, a lime soda softener, and much research equipment.

Iowa is largely an agricultural state. While immense quantities of by-products, such as straws, stalks, and cobs, go to waste every year the farmers secure a very small return from their investment and labor. The utilization of these agricultural wastes presents attractive problems to the chemical engineer and was one of the first projects undertaken by the department. The development of this research has resulted in the acquiring of much special equipment for the work. A semi-commercial plant for the production of adhesives and furfural from corn cobs has been set up in the main laboratory. For the production of paper from corn stalks there is set up on the mezzanine floor a stalk washer, a small cooker, a small beater, a stuff chest, a Jordan refiner, a pulp screen, and sheet-forming machines. The production of wall board from corn stalks having been successfully worked out on a small scale, semi-commercial machinery for the further development of the process is being installed. A one-ton paper beater has been set up in the main laboratory. On the mezzanine floor south of the main laboratory are the Oliver pick-up rolls and the Downingtown board-forming machine for forming the sheets of wall board. These are standard equipment for producing a continuous sheet of wall board 28 inches wide. For drying, a thirty-foot Coe dryer of the type used in several large wall board plants is provided. The work on wall board is being carried out by the Bureau of Standards in coöperation with the Chemical Engineering Department and the Engineering Experiment Station.

The wall board and paper equipment is not used for any instructional work other than research. As already noted, it is the policy of the department to train men with a thorough knowledge of the fundamental operations of chemical engineering rather than to train process men for a given industry. It is quite natural that the greater portion of the graduate work of the department centers around its major activities; that is, water softening and utilization of agricultural wastes. This is in accord with the best educational thought, that each college offers and encourages graduate work along the lines for which it is particularly well fitted so that a superior grade of graduates be produced.

SOME METHODS OF DETERMINING AVOGADRO'S NUMBER

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Students of chemistry and physics are often startled when they learn that the number of molecules in a thimbleful of air is so great that if each of the inhabitants of the United States (125,000,000) were to count one molecule each second it would take about 10,000 years to complete the job; or again that if these molecules were placed side by side they would *encircle our globe* about *one hundred* times. Statements such as these might well startle a student. But though some students accept these statements readily, others wish to know how such a tremendously large number has been obtained. It has been thought advisable to present a few of the methods, especially since we have some ways of arriving at such figures which are easily comprehended by the average student.

It will be remembered that Amadeo Avogadro (1776–1856), the great Italian chemist, over one hundred years ago proposed the hypothesis that equal volumes of all gases under like conditions contained equal numbers of molecules. How many molecules were to be found in a liter or a gram molecular volume was not stated. Some fifty or more years passed before any one felt it would be possible to estimate this number. Loschmidt (1865) appears to have been the first scientist to estimate the number of molecules in one cubic centimeter of a gas, and in some portions of the European continent this value is known as Loschmidt's number. For some years, however, it has been customary to refer to the number of molecules in a gram molecular volume as Avogadro's number. Most chemists and physicists agree that the most probable value of Avogadro's number is 6.062×10^{23} [1] or 606,200,000,000,000,000,000,000. It will be our purpose then to present some methods of determining this immense figure.

From Atomic and Molecular Dimensions

Without doubt the simplest possible way to arrive at an *approximate* value for Avogadro's number is to determine, if possible, the size of atoms or molecules. Such a piece of data, coupled with the value of the volume

[1] Since some students may not be familiar with this method of representing very large or very small numbers, a few examples will be given. It seems increasingly evident that the best way to express a large or small number is to write it down as an integer and multiply it by 10 with the proper exponent. Thus $348 = 3.48 \times 100 = 3.48 \times 10^2$, and $3480 = 3.48 \times 10^3$. In a similar way we have $0.01 = \frac{1}{100} = \frac{1}{10^2} = 1 \times 10^{-2}$ and $0.0348 = 3.48 \times 10^{-2}$. Multiplying 3.48×10^2 by 4.0×10^4 we get 13.92×10^6 or 1.392×10^7. Dividing 3.48×10^3 by 4×10^4 we get $\frac{0.87}{100} = 0.87 \times 10^{-2}$ or 8.7×10^{-3}.

occupied by a gram atom or gram molecule, leads immediately to the desired figure. Several illustrations will now be given. Many investigators have shown that very thin sheets of metal may be prepared. The thinnest gold foil ever made was approximately 5×10^{-7} cm. thick. Michael Faraday[2] claimed to have produced gold foil $^1/_{100}$ wave-length of sodium light, or five millionths of a millimeter. It may be well to mention, too, that in recent years wires of various metals of diameter as small as 2×10^{-5} cm. may be purchased from various manufacturers. It should be quite evident, then, that atoms are smaller than these figures. Other scientists have further shown that very thin uniform coatings of silver may be electrolytically deposited on, say, copper. The important point, for our purposes, is that the properties of copper are lost and those of silver gained when the film reaches a definite thickness, usually about 10^{-7} cm. Electromotive force measurements and observation of the change in phase of reflected light are the properties usually studied to determine when the film is sufficiently thick.

Let us now make a simple calculation assuming a film of silver 5×10^{-8} cm. thick to be composed of only one layer of silver atoms. The atomic weight of silver is very nearly 108, while its density is 8.65, therefore 108 grams of silver have a volume of $\frac{108}{8.65}$ or 12 cc. Now if the atoms of silver are assumed to be spherical in shape, the volume of *one* atom is $\frac{4}{3}\ \pi r^3$ or $\frac{4}{3} \times 3.14 \times \left(\frac{5}{2} \times 10^{-8}\right)^3$ or 8×10^{-23} cc. Since one atom has a volume of 8×10^{-23} cc. and one gram atom occupies 12 cc., the number of atoms in a gram atom is readily seen to be $\frac{12}{8 \times 10^{-23}} = 1.5 \times 10^{23}$. This, it must be emphasized, is only an approximate value of Avogadro's number, since the atomic dimensions used above are only approximate.

Now there is another method of determining the limiting value of molecular dimensions, which yields values which are quite accurate, and yet the principle of the method is easily understood. From a study of oil films on water, Lord Rayleigh, Devaux, Langmuir,[3] and others have shown the thinnest oil films to be about 5×10^{-8} cm. thick. This is done in the following manner. A rectangular trough is scrupulously cleaned and then half filled with freshly distilled water. Fine talcum powder is sifted (through a fine meshed linen cloth) on the surface of the water. Strips of

[2] *Pogg. Ann.*, **110,** 168 (1860).

[3] An article by Langmuir [*J. Am. Chem. Soc.*, **39,** 1898 (1917)] may be read with profit by students interested in this subject. The earlier literature is critically reviewed by Langmuir in this paper.

paper are now used to push all the talc particles to one end of the trough. This procedure is repeated a few times to make sure the surface of the water is very clean. The surface of the water is once more covered with fine talc powder. The appearance of the trough is illustrated diagrammatically in Figure 1. A small weighed amount of one per cent solution of oleic acid (dissolved in benzene) is dropped in the center of the trough; it will be observed immediately that the talc particles are pushed back so that the trough now appears as shown in Figure 2. Strips of paper are now used to get the film of oil in the rectangular shape seen in Figure 3. The length and breadth of the oil film may now be easily measured with a fair degree of precision. Let us now consider a concrete case. When 0.01 gram of a 1% oleic acid solution is dropped on the surface of water, the oil film was found to be 45 cm. long and 20 cm. wide. The area of the film is thus 900 sq. cm. The volume occupied by the 0.0001 gram of oleic acid used is readily found to be 1×10^{-4} cc. as the following calculation shows. Since the molecular weight of oleic acid is 282 and its density is 0.89, its molecular volume must be 313 cc. The simple proportion, $0.0001 : 282 = x : 313$, gives the desired result, 1.1×10^{-4} cc. Now consider the simple relation: area $\times$ thickness = volume, and, substituting, we have the thickness is equal to $\frac{10^{-4} \text{ cc.}}{900 \text{ sq. cm.}} = 1.12 \times 10^{-7}$ cm.

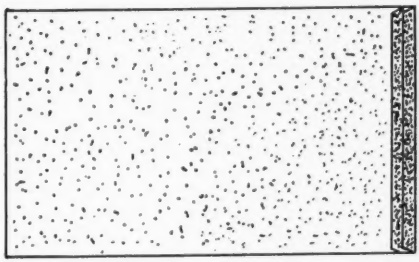

FIGURE 1

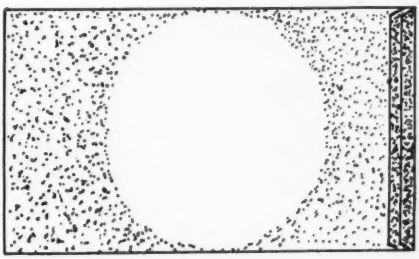

FIGURE 2

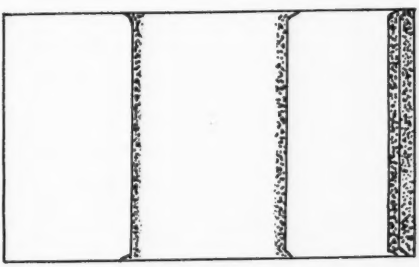

FIGURE 3

Having the dimensions of the molecule of oleic acid, a calculation similar

to the one for silver leads to a value of 6×10^{23} for Avogadro's number, which proves to be a tolerably reliable value.

From Alpha Particles

Such an important constant as Avogadro's number deserves to be determined in as many different ways as is possible. All of the above calculations are based on values of atomic or molecular dimensions. We may now turn to another method which is very different indeed.

Ever since the discovery of that unique element radium, in 1895, a great many fundamental researches have been carried out to determine its varied properties. Some ten years after its discovery, it was shown conclusively that material particles (called alpha particles) were shot off in a definite way. It was proved that the *atom* of radium actually disintegrated into two other elements, radon and helium. If each radium atom lost one alpha particle the original atomic weight of 226 was reduced by four units (the atomic weight of helium) giving radon with an atomic weight of 222. Now it is all important to note that these alpha particles on acquiring two electrons become helium atoms; helium being a perfectly respectable gas now used in large quantities to fill dirigibles. If we can obtain a method of counting the alpha particles emitted in a given time, and in a separate experiment determine the volume of helium evolved in the same time from a given quantity of radium, we have an elegant method of determining Avogadro's number. Sir Ernest Rutherford, professor of physics in Cambridge University (England), has developed beautiful methods for counting the alpha particles, while the late Sir James Dewar, of the Royal Institution of Great Britain, has determined the volume of helium evolved from a given quantity of radium in a year. The experimental methods deserve a little more detailed discussion.

It so happens that each individual alpha particle shot off from radium can be rather easily detected. Since its kinetic energy is very large, due to its high velocity (about 18,600 *miles* per *second*), we have only to allow the particles to impinge on a thin film of zinc sulfide (on glass); we then see a bright flash of light (under a low power microscope) each time an alpha particle strikes the zinc sulfide.

Rutherford and co-workers used the apparatus[4] shown diagrammatically in Figure 4. In a long glass tube is placed a small amount of a radioactive material, usually a thin film on the point P. At A we find a small circular aperture, while at Z is the phosphorescent zinc sulfide screen; at M is placed a low power microscope having a field about twice the area of the aperture.

In one typical experiment of Rutherford about 67 milligrams of the radioactive material was placed on the point P, which was 200 cm. from

[4] *Proc. Roy. Soc.*, **81A**, 141 (1908). Cf. Regener, *Verhandl. deut. physik. Ges.*, **10**, 78 (1908).

the aperture A of diameter 0.0615 cm. Thirty particles were observed per minute. The ratio of the areas of the sphere (of 200 cm. radius) and the aperture is given by $4\pi r_1^2$ (area of sphere) or πr_2^2 (area of aperture); $\frac{4 \times (200)^2}{(0.0615)^2} = 4.5 \times 10^7$; therefore $30 \times 4.5 \times 10^7$ or 135×10^7 alpha particles are being given off each minute or 2.25×10^7 per second. Now it is

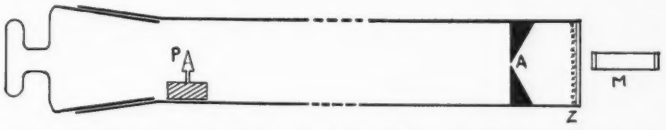

FIGURE 4.—APPARATUS FOR COUNTING ALPHA PARTICLES EMITTED FROM RADIUM

easily seen that one gram of radium would give off $\frac{226}{0.067} \times 10^7 = 3.1 \times 10^{10}$ particles per second.

In as much as it is a tedious process to count many thousand of these flashes of light, electrical methods have been developed to count the particles. The actual apparatus developed by Rutherford is shown in Figure 5. It will be noted that the detecting vessel consists of a (brass) cylinder A, with a central insulated wire B passing through ebonite corks at the ends. The central wire is connected to a very sensitive electrical instrument called an electrometer. When an alpha particle passes through the aperture into the detecting vessel a sudden ballistic throw of the electrometer needle is noted. This can be detected with the eye or more con-

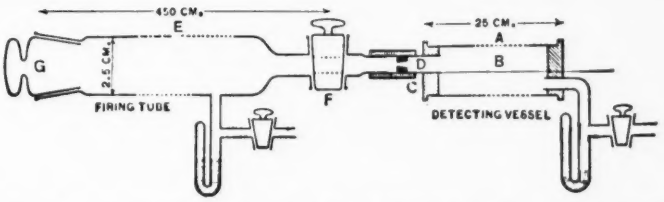

FIGURE 5.—RUTHERFORD AND GEIGER'S APPARATUS FOR ELECTRICALLY COUNTING THE ALPHA PARTICLES

veniently by photographic means as has been done by Rutherford.[5] A photographic record of the alpha particles entering the detecting vessel is shown in Figure 6. It is a simple matter to count the throws of the needle in a given time, after the film is developed. The line A shows the part of the record obtained when the film moved at the rate of 13 cm. per minute,

[5] *Phil. Mag.* (6) **24**, 618 (1912).

and for an average of 50 alpha particles per minute. The length shown on the photograph corresponds to about one minute. The line *B* corresponds to a film movement of 180 cm. per second and for about 600 alpha particles per minute, while the line *C* corresponds to an average of 900 alpha particles per minute.

TABLE I

Distance of active body from aperture, cm.	Milligrams of radium on point source	Number of throws in 10 minutes	Number of alpha particles expelled per gram
350	0.309	45	3.06×10^{10}
350	0.154	25	3.33×10^{10}
350	0.11	16	2.96×10^{10}
150	0.055	49	3.43×10^{10}
150	0.031	25	3.11×10^{10}
		Average	3.18×10^{10}

Some of the most accurate results of Rutherford obtained by the electrical method are given in Table 1.

In the electrical method one slight correction is necessary, because of the size of the wire in the detecting vessel, amounting to about 3%; the corrected value is 3.4×10^{10} alpha particles per second per gram of radium.

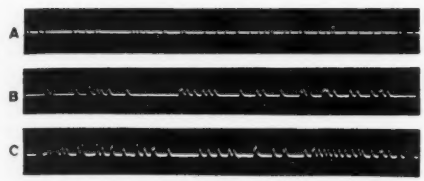

FIGURE 6.—PHOTOGRAPHIC RECORD OF NUMBER OF ALPHA PARTICLES EMITTED FROM RADIOACTIVE MATERIALS

Now Dewar[6] in a careful research found the amount of helium evolved from 70 milligrams of radium chloride in nine months. The small volume (about 9 *cubic millimeters*) of helium developed made it necessary to use high vacuum technic: very efficient vacuum pumps, charcoal cooled by liquid air, and a McLeod gage capable of being read to about 1×10^{-6} millimeters of gas pressure.[7] On reducing Dewar's data and that of independent investigators to the volume of helium developed by one gram of radium in one year we get the value 39 cubic millimeters. This is a very important constant.

Now it will be recalled that 3.4×10^{10} alpha particles are expelled from one gram of radium in one second (or 107.5×10^{16} per year); and further, each of these particles, on acquiring two electrons, become actual helium atoms. Since 39 cubic millimeters of helium are developed from the same quantity (1 gram) of radium it must be evident that 39 cubic millimeters

[6] *Proc. Roy. Soc.*, **83A,** 404 (1910).

[7] For an interesting article on high vacuum see Bartlett, THIS JOURNAL, **4,** 604 (May, 1927).

of helium contain 107.5×10^{16} *atoms* of helium. A simple proportion gives us the number of atoms in 22,410 cc. of helium; the figure is 6.14×10^{23}.[8]

From the Quantity of Electricity Associated with an Electron

The last method we will discuss is considered to be the most precise, being based upon the electrical quantities found on a single electron and on an equivalent of univalent atoms; the latter quantity is called a Faraday of electricity.

In an earlier paragraph it was pointed out that silver could be deposited electrolytically on a copper plate. The chemical reaction that takes place may be written as follows: $Ag^+ + \text{electron} = Ag^0$; the silver atoms in solution being ionic (carry a charge), while in the metallic state the atoms are electrically neutral.

Some seventy years ago Michael Faraday, after considerable, careful experimentation, showed that equivalent amounts of metals would be deposited on passing equivalent amounts of current through various solutions; for instance, a definite amount of current would cause 107.88 grams of silver to be deposited from an $AgNO_3$ solution, $\frac{63.57}{2}$ grams of zinc from a $Zn(NO_3)_2$ solution. The amount of current necessary to do this—called a Faraday of electricity—is 96,500 coulombs,[9] or $96{,}500 \times 3 \times 10^9 = 2.89 \times 10^{14}$ electrostatic units.

Now if the quantity of electricity associated with a single electron is known our problem would be solved. Millikan[10] appears to have done this more accurately than any one else by the so-called "balanced drop method." A small droplet of oil is caused to appear between two plates of a condenser (see Figure 7). A detailed sketch of the actual apparatus employed by Millikan is shown in Figure 8.[11] The description at the bottom of the figure will no doubt suffice for the present paper. If no charge is found on the plates of the condenser the oil droplet will fall under the influence of gravity according to the well-known law of Stokes. A number of observations are made of the rate of fall of the drop under these conditions. The plates are now charged to a high voltage. If the rate of

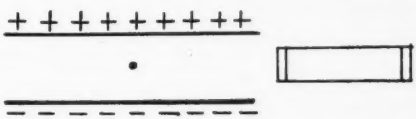

FIGURE 7.—DIAGRAMMATIC SKETCH OF THE BALANCED DROP METHOD

[8] We have purposely avoided the complicated concept of "radium in equilibrium" in this elementary presentation.

[9] A coulomb is one ampere flowing for one second.

[10] Nobel laureate in physics; formerly of the University of Chicago—now at the California Institute of Technology.

[11] Taken from Millikan, "The Electron," Univ. of Chicago Press, Chicago, Ill., 1917.

fall of the particle is not changed the drop is neutral and is made to acquire one electron by allowing x-rays or radium rays to play upon it. Now since the particle is charged negatively, by charging the upper plate positively, a certain voltage can be applied such that the droplet neither rises nor falls—hence the name "balanced drop method." Rather simple calculations[12] lead to the value 4.774×10^{-10} electrostatic units for the amount of electricity associated with a single electron.

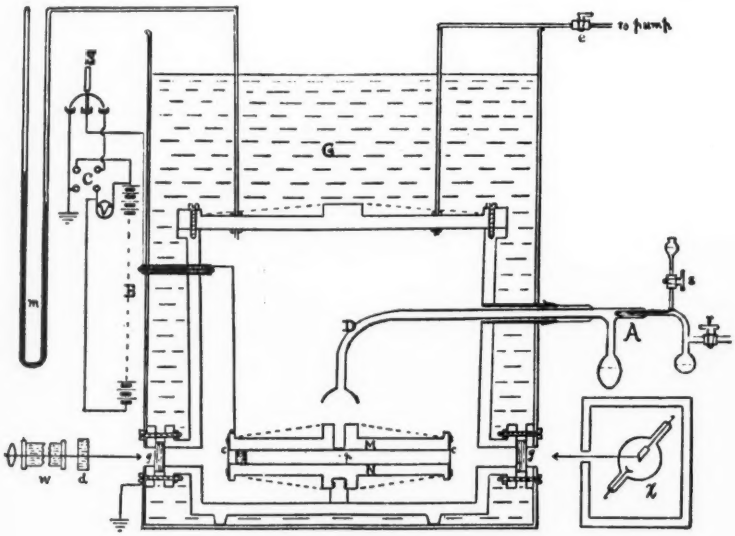

FIGURE 8

A, atomizer through which the oil spray is blown into the cylindrical vessel *D*. *G*, oil tank to keep the temperature constant. *M* and *N*, circular brass plates, electrical field produced by throwing on 10,000-volt battery *B*. Light from arc lamp *a*, after heat rays are removed by passage through *w* and *d*, enters chamber through glass window *g* and illuminates droplet *p* between plates *M* and *N* through the pinhole in *M*. Additional ions are produced about *p* by x-rays from the bulb *X*.

It will be remembered that 2.89×10^{14} e. s. u. are associated with one gram atom of a univalent element; only 4.77×10^{-10} e. s. u. are associated with a single univalent atom, therefore the number of atoms in one gram atom is $\frac{2.89 \times 10^{14}}{4.77 \times 10^{-10}} = 6.06 \times 10^{23}$. This figure is believed to be quite precise.

[12] For the method of calculation and a great many details which have been necessarily omitted, see Palmer, *J. Optical Soc. Am.*, **7**, 873 (1923).

Comparison of Results

In Table 2[13] will be found a list of the more important methods of determining Avogadro's number, along with the observers and the values obtained.

TABLE II

Observer	Method	Molecules per gram-molecule
	Mean free path of a molecule	5 to 6 $\times 10^{23}$
Perrin	Brownian movement of colloids	6.8
Svedberg	Intensity of Brownian motion	6.2
Brillouin	Intensity of Brownian motion	6.9
Fletcher	Rate of fall of oil drops in air	6.03
King	Scattering of solar radiation	6.2
Pacini	Scattering of solar radiation	5.7
Rutherford	Charge on an alpha particle	6.0
Millikan	Determination of unit electric charge	6.06 ± 0.01
Planck	Radiation laws	6.06
Perrin	Angular displacement of a colloidal particle	6.5
Boltwood	Alpha particles in helium from radium	6.3
Curie	Alpha particles from polonium	6.5
Rutherford	Kinetic energy of an alpha particle	6.2
Westgren	Change of distribution of colloidal particles	6.09

It seems remarkable that these values agree with one another so well, especially as one considers the great variety of methods employed. From measurements of very thin gold foil, or thin films of oils, from the study of radioactive materials—to the color of the blue sky up in the Alps,[14] we find that important constant of Nature, Avogadro's number, recurring again and again. It is to be hoped that the reader on studying the various methods of determining Avogadro's number will not pass over lightly that ever-remarkable *fact* that everywhere about us are almost infinite numbers of atoms and molecules.

[13] This table is taken from Millard, "Physical Chemistry for Colleges," McGraw-Hill Book Co., New York, **1926**; *Gen. Elec. Rev.*, **18**, 1159 (1915).

[14] The work of Pacini reported in Table II was done at an elevation of nearly one mile above sea level in an attempt to get far above the dust and smoke of the cities. The experimenters made observations on the color of the blue sky at every available moment. Lord Rayleigh had predicted that Avogadro's number would be found of importance in interpreting the phenomenon of the scattering of light; and Pacini's calculation of Avogadro's number gives strong support to Rayleigh's theory.

Minerals in Plants Studied with X-Rays. Mineral deposits in the joints of plants, which sometimes have detrimental effects, have been studied by a method new in plant physiology though old in surgery, x-rays. At the recent meeting of the American Society of Plant Physiologists, C. L. Crutchfield of Honolulu told of his researches on sugar cane with the penetrating rays. In addition to their use in locating accumulations of minerals, they may also be effective in studies on the path of nutrients in solution through the stem.—*Science Service*

THE DENTIST'S PROBLEM—SATISFACTORY MATERIAL FOR RESTORING TEETH

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From Mount Vernon in 1799, George Washington wrote to John Greenwood, a dentist in New York, complaining that his "sett" of false teeth had turned dark. The dentist replied that the discoloration was probably caused by drinking port wine which is "sour and acid and has a tendency to soften every kind of teeth." The artificial teeth of those days were carved from bone or ivory and were fastened to metal plates. They were crude in appearance as well as efficiency.

Early dentistry in the American colonies was far from a highly developed profession. It was practiced usually as a side line to barbering or to some mechanical trade. Paul Revere in Boston was both a silversmith and a dentist. The instrument maker or the ivory worker often undertook to make dental restorations. But in the early part of the 19th century the profession of dentistry began to make progress. Men who had the advantage of medical education took up dental work, and efforts began to be made to apply the sciences and arts to the profession. Advancement, however, was at first slow, but from about 1850, when Goodyear applied his discovery of vulcanite to the making of dental plates, many modern changes have taken place.

The dentist's work has always been chiefly that of restoration—rebuilding lost or broken down teeth—and his chief problem has always been that of obtaining satisfactory materials for the purpose. And the chemist and metallurgist have been great aids to the dental profession in supplying satisfactory materials for reconstructing teeth. When the manufacturers of dental supplies began to employ competent chemists to devote themselves to the problems of dental materials, it was but a short time until the present stage of excellence was reached.

Materials for Filling Teeth

Throughout the history of dentistry we find a constant search for new and better materials which could be used for filling cavities in teeth. In quite early times pure gold, tin, and lead in malleable forms were used to a limited extent—limited by the skill of the operator. With the revival of dentistry about 1800, pure gold in the form of foil came into general use. It was discovered that, when properly annealed, gold foil could be malleted into a cohesive mass and the contour of the tooth could be built up and restored.

Plastic amalgams (preparations of silver and mercury) were first introduced from France and England about 1830. The oldest form of amalgam was made by filing Spanish coins and mixing with mercury. Some study

of the problem and some improvement was made but it was not until 1897 that Dr. G. V. Black worked out a formula for a scientifically balanced alloy—balanced proportions of silver and tin to control expansion and shrinkage, and strength.

Plastic cements (zinc oxychlorides and zinc oxyphosphates) were first used about 1860 to 1880. Great improvements have been made. The so-called silicate cements, "synthetic porcelain," have come into use in the past 10 years. They are more durable than the oxyphosphates and with them the natural tooth colors can be accurately matched. The gold inlay is a late and modern addition to materials for restoring tooth structure. Alloyed with silver and copper for strength it approaches the ideal filling material for teeth bearing the stress of mastication.

Requirements of Filling Materials

The dentist continues to seek new and improved materials for filling teeth. Few of the materials now available can be regarded as perfect from his standpoint.

A list of the requirements of a perfect filling material is about as follows:

1. The material should be indestructible in the fluids of the mouth. It must be remembered that saliva is ordinarily somewhat acid and all cements and even some amalgams are slowly dissolved out in the mouth.
2. The material should have adaptibility to the walls of the tooth cavity, *i. e.*, the dentist should be able to mallet or tamp it to place.
3. It must be free from shrinkage or expansion after placing in the tooth.
4. It must be hard enough to resist the attrition and wear of mastication.
5. It must be strong and tough to prevent fracture or displacement by the stresses of mastication.
6. The material should have a good color and appearance. If possible it should be available in shades to match the color of tooth structure.
7. It is highly desirable that the filling material should be a non-conductor of thermal changes—heat and cold.
8. It must be remembered that filling material is placed in a living tooth and it must have no toxic effect on the pulp or "nerve."
9. The material should be easy to manipulate, not only readily prepared or mixed, but, if plastic, it should harden promptly when inserted in the tooth.

No material available today for filling teeth possesses all of these desirable qualities. Some materials, like the gold inlay and silver amalgam, possess enough of these properties to make them satisfactory: some, like the cements, are used because nothing better is available.

The Gold Inlay

The gold inlay for restoring posterior teeth which must stand the stress of mastication is more nearly ideal for that purpose than any other material the dentist has. Gold alloyed with silver and copper for hardness and

strength, will, when properly inserted in a tooth, restore that tooth to function permanently. The gold inlay is not affected by mouth fluids nor will it discolor. In posterior teeth the color of gold is not objectionable. Gold has another desirable property in that it exerts an antiseptic effect on the tooth structure, and decay is not likely to recur along the margins of the inlay if it is well fitted and cemented into the tooth. A restoration with a good inlay is permanent.

The main objection to the gold inlay is that it is not easily made. A good deal of tooth structure must be cut away since no overhanging walls may be allowed to remain. A wax pattern is prepared in the tooth cavity and carved to form. This is carefully lifted out, invested in a fireproof material and burned out. Molten gold is then forced into the mold by air pressure. Since several hours of work are required to carve, cast, and polish an inlay, the dentist is required to charge a comparatively high price for it.

Silver-Tin Amalgam

The most universally used material for filling posterior teeth is silver-tin amalgam—the so-called silver filling. Its greatest advantage is the ease with which it may be inserted, yet results are directly proportionate to the care and the skill of the operator. The modern silver-tin alloys supplied by the dental manufacturer today are probably as good as can be produced and when properly manipulated by the dentist a hard and strong filling can be made. While the restoration of a tooth with amalgam can be said to be permanent, yet as a filling material it is not as durable as the gold inlay. Decay may recur along the margins of the filling and in some mouths amalgam discolors readily. Its advantage over the gold inlay is that it is more easily inserted and is therefore cheaper. Silver-tin amalgam has saved a great many teeth for patients who could not afford gold.

Restorations for Anterior Teeth

When front teeth have cavities in them and must be restored, the most important consideration is appearance. The material must match the shade of the tooth and also have a certain degree of translucency. Silicate cements are now generally used by the dentist for this purpose and of all the filling materials they are the most unsatisfactory. Beautiful tooth restorations can be made with silicate cements and while certain precautions of dryness must be observed, the material is not difficult to handle. The chief objection is that they dissolve out in the fluids of the mouth and they are not permanent fillings. There are also other faults. Phosphoric acid, which is used in mixing seems not to be completely used up in the process of setting and this acid acting for a time in the cavity under the filling will not infrequently cause the death of the pulp or "nerve" of the

tooth. The dentist is greatly in need of an improved plastic material for filling anterior teeth. The baked porcelain inlay can be used in very few cases, special skill being needed and the price being prohibitive.

The field of modern dental cements has developed quite recently and improvements are to be looked for. It is not too much to expect of the chemist that he will improve them to a point where objectionable features are overcome.

Dental Cements

Dental cements are of two main types. First, the zinc oxyphosphates which are used for true cementation as for inlays and crowns, and second, what are known as "silicate" cements used for filling cavities in anterior teeth where esthetics require an invisible restoration. The silicates are more translucent and more durable.

All cements are furnished by the manufacturer in the form of an acid liquid and a basic powder. When the two are mixed a new compound is formed accompanied by the usual phenomena exhibited when an acid and base are brought together. The exact formulas for the various cements to be had on the market are more or less secret and guarded by the manufacturers. In general, however, their formulas are known. The following information is taken from Dr. Marcus L. Ward's "Studies of Dental Materials."

Cement Liquids

The liquids which are used with dental cements are mixtures of orthophosphoric acid, aluminum hydroxide, and water, in about the following proportions:

Ortho-phosphoric acid (85%)	79%
Aluminum hydroxide	10%
Water	11%

The aluminum hydroxide partially neutralizes the acid and so modifies it that less heat is generated when the cement is mixed, and the setting of the mass, which would otherwise be very rapid, is retarded. The aluminum phosphate formed by the liquid mixture probably also aids the setting of the cement in the presence of moisture, a property which is quite important in dental cements. Water is added to the phosphoric acid for a definite purpose. The acid in dilution not only acts as a better solvent but the water apparently takes part in the chemical reaction with the powder, improving the physical properties of the cement after it has set. The addition of more water will hasten the setting and the subtraction of water will retard it.

Cement Powders

The powder portion of the first type of dental cements is zinc oxide modified to develop certain qualities. When unmodified zinc oxide combines with phosphoric acid the setting is very rapid and the mass is weak and lacks adhesion. The desired properties in the zinc oxide seem to be developed by changing the physical form of that compound. Calcination of the zinc oxide is one method. As it is calcined it turns slightly yellow and takes on the appearance of powdered glass. It becomes less soluble and reacts much less rapidly with phosphoric acid. Another method of modifying zinc oxide consists of dissolving it in nitric acid and evaporating to dryness. The zinc oxide thus produced from the nitrate is similar to the product prepared by calcination except that the particles of the powder are in uniform, fine size and shape. With the calcination method the particles of zinc oxide may be of all sizes and shapes. But by either method of modifying the cement powder, its properties for dental purposes are much improved.

Certain chemical compounds are usually added to the modified zinc oxide. Bismuth trioxide aids in producing a smooth mass. The proper color or shade is produced by the addition of manganese dioxide for the gray powders and ferric oxide for the yellow and brown. Small percentages of copper or silver salts are added to some cements to develop germicidal and antiseptic properties.

Silicate Cements

The so-called silicate cements are the result of recent researches in an effort to produce a product more translucent and less soluble than zinc cements. The aim has been to get a cement which would be durable enough and translucent enough to use as a filling material for the anterior teeth where appearance is important. Such materials as silicon dioxide, calcium oxide, and aluminum oxide are made to form a powder which, when mixed with a liquid composed of phosphoric acid, water, and metallic oxides, sets in much the same manner as zinc cements.

The exact formulas for silicate cements now on the market are carefully guarded by the manufacturers and seem to be very complex. It has been stated in literature on the subject that to the ingredients mentioned there are added certain fluorides to permit the powder mass to fuse at a lower temperature; that oxides of aluminum, calcium, zinc are used in solution in the phosphoric acid mixture; that acid anhydrides such as the oxide of phosphorus may also be present in the powder portion. Whatever the effect of such additional compounds may be, the manufacturer has been able to develop a silicate cement that is more translucent and more insoluble than zinc cement although it is less adhesive and less tough and must be carefully protected from moisture during manipulation. But at

its best a filling made with silicate cement does not hold up well in the mouth and cannot be regarded as a permanent tooth restoration.

Field for Study in Dental Cements

There is yet much to be learned of the chemistry and physics of dental cements. The cements that are available today do not possess nearly all the properties desired by the dentist. What these desirable properties are may be summarized as follows:

1. Permanency and insolubility in the fluids of the mouth.
2. Constancy of volume.
3. Resistance to stress.
4. Adhesion.
5. Density and non-porosity.
6. Suitable rate of setting.
7. Color and translucency to match tooth shades.
8. Absence of toxic action on the pulp of the tooth.
9. "Hydraulicity" or the ability to set in the presence of moisture.
10. Ease of manipulation.

It is likely that some of these dental requirements will be difficult to meet. But the dentist is confident that the chemist will continue to study dental cements and eventually give him a formula that will answer most if not all his requirements. The dentist's greatest problem has always been that of finding satisfactory materials for restoring teeth and with the aid of the chemist his problem is on the way to satisfactory conclusion.

Seek to Simplify Production of Insulin. A new and simpler way of making insulin, the great boon to diabetics, may result from studies now being made. Prof. John J. Abel, who was the first to make pure crystalline insulin, reported recently to members of the American Association for the Advancement of Science that probably only a part of the complex insulin molecule is responsible for the action of the substance. In that case, it will probably not be necessary to build up the whole complex structure in order to get an active compound.

Prof. Abel and Dr. H. Jensen of the Johns Hopkins School of Medicine are now studying the chemical composition and structure of insulin, which is a substance secreted by the pancreas which acts to regulate the body's utilization of sugar. Lack of insulin results in the disease known as diabetes. Drs. Banting, MacLeod, Collie, and Best of the University of Toronto were able to prepare a pancreatic extract which contained insulin and was effective in treating diabetes. Prof. Abel and associates later succeeded in synthesizing the crystalline insulin. Insulin is of protein nature.

"The outstanding characteristic of crystalline insulin in comparison with other proteins is its high sulfur content (3.1 to 3.2%) and its instability toward alkali," said Prof. Abel. Crystalline insulin has a very powerful action. The average daily dosage of insulin given to a patient suffering from diabetes would correspond to 1 mg., or about one-hundredth of a grain, of crystalline insulin.—*Science Service*

KNOW YOUR FOODS. III. CANNED FOODS*

H. A. SCHUETTE, UNIVERSITY OF WISCONSIN, MADISON, WISCONSIN

On a previous occasion we referred to the fact that the oleomargarine industry is the product of French ingenuity, and that to a chemist named Mège Mouries goes the credit for having first made butter's chief competitor. And now we turn again to this nation to find the sponsor of another industry, that of canning foods.

We will follow our subject not so much from the standpoint of methods used by the commercial canner in operating his factory, nor yet as a discussion of the economic importance which attaches to this industry, but rather more so from the historical side. And then, for good measure, we will make a few timely comments on vitamins in canned foods.

The father of the canning industry was Nicholas Appert, a Frenchman. Perhaps one is guilty of committing an anachronism in referring to Appert as a canner for he lived in a tin-canless age, the tin can representing a distinct development of a later day. What Appert actually did—and his successors are still doing the same thing today under a different name—was to preserve foods by hermetically sealing them in glass jars or bottles whose corks were luted with a cement made of slaked lime and skim-milk.

In the year 1795 France had a revolution on its hands at home and was at war with nearly all of Europe on land and sea. The government wanted some way of supplying fresh provisions to its sailors, for even at that early date[1] it was known that scurvy resulted from the absence of fresh foods, especially vegetables, in the diet.

No one had ever successfully preserved fresh vegetables or fruits before. Drying, salting, smoking, and pickling were practically the only known methods of keeping foods from one season to another. For this reason the French government was quite willing to pay a goodly sum of money to anybody who would find a way of supplying fresh, health-giving provisions to its sailors.

Appert set out to win that prize of 12,000 francs, which was roughly equivalent to $2500, in 1795. Ten years later as a result of "reflection, investigation, long attention, and numerous experiments" he was successful in preserving nearly every kind of fresh food—fruits, vegetables, meats, fish, and even eggs and cooked dishes—to the end that they could be kept for years. His process of cooking and sealing up foods was so simple that any one with any knowledge at all of the culinary arts could follow it.

It is quite remarkable that he should have been so successful in his undertaking for he was a man of probably but little schooling, it is believed,

* A lecture broadcast by radiophone from Station WHA, University of Wisconsin, March 21, 1928.

[1] Lind, James, "A Treatise on Scurvy," London, 1757.

and certainly no scientific education. Yet what he may have lacked in this direction was overshadowed by a broad practical experience. But let him tell of himself in his own words:

Brought up to the business of preserving alimentary substances by the received methods; having spent my days in the pantries, the breweries, store-houses, and cellars of Champagne, as well as in the shops, manufactories, and warehouses of confectioners, distillers, and grocers; accustomed to superintend establishments of this kind for forty-five years, I have been able to avail myself, in my process, of a number of advantages

Courtesy of Glass Container Association of America

N. APPERT

which the greater number of those persons have not possessed, who have devoted themselves to the art of preserving provisions.[2]

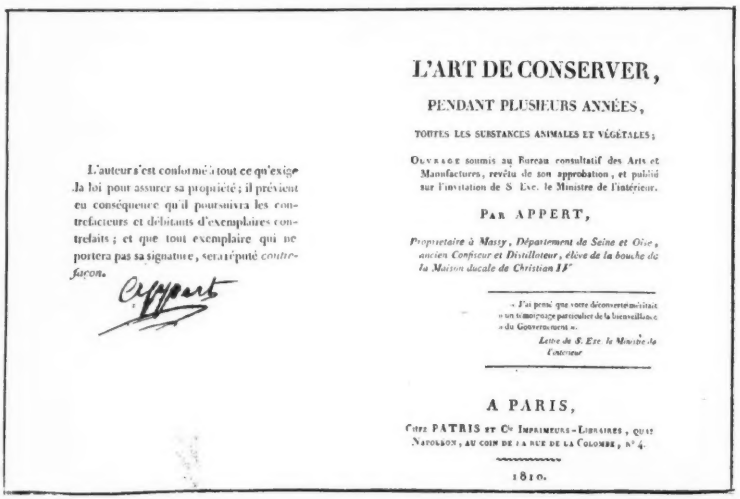
One of the conditions of the contest was that the successful inventor must describe his process in a book, so that France could give it to the world. Upon the recommendation of the Paris Society for the Encourage-

[2] Appert, "The Art of Preserving All Kinds of Animal and Vegetable Substances for Several Years," pp. 7–8. (Trans. from the French), London, 1811.

ment of National Industry, Appert was awarded the prize. He described his process in a book entitled "The Art of Preserving All Kinds of Animal and Vegetable Substances for Several Years." It appeared in 1810 and was translated from the French by an unknown author the next year. Several years ago another English translation was made by Mrs. K. Bitting.

One gathers that appreciation of the importance of his discovery was immediate, as the following paragraphs from the translator's preface to his book bear witness:

It is needless to anticipate. . . . the advantages which must flow from a simple and unexpensive process of keeping fresh articles of animal and vegetable food. If this can



L'auteur s'est conformé à tout ce qu'exige la loi pour assurer sa propriété; il prévient en conséquence qu'il poursuivra les contrefacteurs et débitants d'exemplaires contrefaits; et que tout exemplaire qui ne portera pas sa signature, sera réputé *contrefaçon*.

Appert

L'ART DE CONSERVER,

PENDANT PLUSIEURS ANNÉES,

TOUTES LES SUBSTANCES ANIMALES ET VÉGÉTALES;

OUVRAGE soumis au Bureau consultatif des Arts et Manufactures, revêtu de son approbation, et publié sur l'invitation de S. Exc. le Ministre de l'intérieur.

PAR APPERT,

Propriétaire à Massy, Département de Seine et Oise, ancien Confiseur et Distilleteur, élève de la bouche de la Maison ducale de Christian IV

« J'ai pensé que votre découverte méritait » un témoignage particulier de la bienveillance » du Gouvernement ».

Lettre de S. Exc. le Ministre de l'intérieur

A PARIS,

CHEZ PATRIS ET Cie IMPRIMEURS-LIBRAIRES, QUAI NAPOLÉON, AU COIN DE LA RUE DE LA COLOMBE, N° 4.

1810.

FRONTISPIECE OF AUTOGRAPHED COPY OF APPERT'S "L'ART DE CONSERVER."

be effected for only *one year*, that is, from the season of produce through the seasons of scarcity; if no other articles, for instance, than eggs, cream, and vegetables, can be preserved in their full flavour and excellence during a long winter, there is not a mistress of a family in the kingdom, rich enough to lay by a stock of those articles, and not too rich to despise the economy of a family, who will not find herself benefited by the perusal of the small work here put within her reach; and there is no reason to suspect the correctness of this part of the author's statements. This, however, is but one of the more obvious benefits of his process; and if this much be ascertained, then an interminable prospect of resources is opened, which the State, still more than the individual, will be called upon to employ.[3]

The essential features of his process consisted in packing the food product into wide-mouthed glass bottles with water and corking them loosely, then in

[3] Translator's preface to Appert's "Art of Preserving," vii–ix, 1811.

placing the bottles in a water-bath kept at or near its boiling point for the required length of time; and finally, after removal of the bottles, of sealing them by driving the corks in tightly and making them air tight with a sort of casein glue. He considered glass "as the matter most impenetrable to air," and believed that "external air" as such was the cause of spoilage, although he believed air subjected to heat in the glass jars was not capable of causing spoilage because "it had been rendered of no effect by the action of the heat." One may very well conclude from these statements that he had neither a very clear conception of the relation of bacteria to spoilage nor of the real signification of sterilization. When viewed in the light of modern bacteriology, it appears that Appert's was rule-of-thumb discovery made by one who was not a trained scientist but one who had, in a sense, made himself one by observation and thinking.

Without the aid of a chemist or a bacteriologist, he had made his process so sound scientifically that it is the basis of our canning industry today. To be sure we do everything better today than did Appert, yet not very differently. We use sanitary tin cans which he, we are sure, would have thought marvelous, and automatic machinery for handling the food so that it need not be touched by human hands, and machines for cooking and sterilizing with steam under pressure. Appert discovered that food in air-tight packages could be sterilized with heat so that it would keep, and heat is still the only sterilizing agent that canners use to preserve the large number of foods that are now packed.

Appert packed his foods in specially made glass bottles for no other known containers at that time served his purposes. An Englishman by the name of Durand introduced the use of the tin "cannister," a word subsequently shortened by lazy invoice clerks to "can"—and can it has remained ever since. The choice of material for the packaging seems to be slowly swinging back again to the glass container of Appert's time. And it is probably well that it is, for one need not seek very far to find very good reasons why glass might not now in turn be advantageously substituted for the tin can, for in reality the latter is only thin sheet iron covered with the thinnest veneer of tin.

A problem which was not timely with the early canners, except in so far as one may read into the inception of the industry a desire to find a preventive for scurvy in the crews of the ships at sea, but which has now become a pertinent one because of our newer ideas of nutrition, is what effect, if any, do modern canning methods have upon the vitamin content of foods.

That vitamins are not affected by heat to the extent formerly believed is now commonly accepted. There has not been reported to date any experimental evidence which indicates that canned foods are less nourishing than ordinary cooked foods. It has been established rather conclusively that vitamins A and D are not appreciably affected by the heat which is

applied in cooking or in processing canned goods, for canned goods are practically as rich in these vitamins as are the corresponding raw products. The situation with respect to vitamin B is somewhat confused, but the probability is that the same holds true for it also. There is now considerable evidence that commercially canned foods are richer in vitamin C than are the same foods when home cooked, for certain conditions in the sterilizing process that canned foods receive, but which do not obtain in home methods of preserving, are such that they tend to preserve, rather than to destroy this vitamin.

One may very well conclude from a consideration of all the experimental evidence on the subject that it is possible to select a diet entirely of canned foods which is complete and adequate for long-continued nutrition. In such a diet all the known vitamins will be present in sufficient amounts.[4]

To make such a diet as palatable, economical, and convenient as can be obtained elsewhere is the problem of the canner. And this he has done in a manner which is a tribute to scientific experimentation, direction, and control.

Additional References

1. W. V. Cruess, "Commercial Fruit and Vegetable Products," McGraw-Hill, New York, **1924.**

2. J. H. Collins, "The Story of Canned Foods," Dutton & Co., New York, **1924.**

[4] E. F. Kohman, "Vitamins in Canned Foods," *Bull. 19-L* (revised), Natl. Canners Assoc., **1927,** p. 5.

Pulleys, Not Hearts, Raise Sap in Trees. Sap does not rise in trees, it gets pulled up. There are no hearts or other pumps, and the mysterious "root pressure" that used to be talked about is little more than a myth. And water, though "as weak as water" in large masses, is as strong as wire when confined within the walls of the tiny tubes that make up the sap-wood of trees.

These are elements in the picture of the inside of a plant's water-distributing system, worked out by Dr. D. T. MacDougal of the Desert Laboratory, Tucson, Ariz., who lectured recently before the Carnegie Institution of Washington. One of Dr. MacDougal's most recent discoveries is that the air confined in the dead vessels of a tree trunk forms a single connected system, just as the sap does. By applying pressure instruments to different parts of the tree's anatomy, he discovered that changes of pressure in one part of the confined air were rapidly transmitted to all parts of the tree.

The paradox of water having a tensile strength, and holding up a weight as though it were made of wire, is the problem that has engaged Dr. MacDougal's major attention for several years. Pioneer work in the same field was done by a British plant physiologist, Dr. H. H. Dixon, and other workers on the Continent. These experiments have shown that as water evaporates from the surface of the leaves it creates a condition of tension in the interior. This tension is transmitted through the leaf-stem and branches to the trunk and down to the roots that draw upon the water supply in the soil.—*Science Service*

THE CHAIR OF CHEMICAL EDUCATION AT THE JOHNS HOPKINS UNIVERSITY

NEIL E. GORDON, THE JOHNS HOPKINS UNIVERSITY, BALTIMORE, MARYLAND

The numerous inquiries about the Chair of Chemical Education, provided by Francis P. Garvan, President of the Chemical Foundation, seem to warrant a few preliminary remarks at this time. This Chair is located in the Chemistry Department of The Johns Hopkins University and has for its primary objective the promotion of chemistry through chemical education. There are two principal projects being developed at the present time—one is connected with the regular chemical work of the scholastic year and the second is associated with the summer session of the university.

Graduate Work in Faculty of Philosophy

During the scholastic year, there is a program of study in the selection and education of prospective leaders in the field of chemistry. In the study to be pursued, equal emphasis is to be laid upon the selection of men to be trained and the training of men selected. In order to limit the project and, at the same time, place it upon a truly national basis, the plan adopted makes ultimate provision for one student from each of the forty-eight states. Selection is to be made from the sophomore, junior, or senior classes of the colleges and universities of the respective states. The time of selection is indicated by the desirability of obtaining students as soon as possible after they have had reasonable opportunity to determine the field in which they desire to specialize. It is, furthermore, in harmony with the present plan of the Johns Hopkins University, which affords the student an opportunity to acquire the Ph.D. degree in a minimum of four years after the completion of the sophomore year.

The selection is accomplished through state committees which evaluate the student's complete previous scholastic record and the following personal qualities as rated by his instructors.

(1) Health	(5) Persistency	(9) Reliability
(2) Ability to coöperate	(6) Faculty of observation	(10) Conduct
(3) Creative ability	(7) Enthusiasm	(11) Morality
(4) Intellectual honesty	(8) Initiative	(12) Scholarship

As an assurance that men of unusual promise shall not be debarred by lack of funds, a four-year fellowship of one thousand dollars annually will be offered in each state.

Among the fellowships to be thus offered are those established by: The Eli Lilly Company of Indianapolis, Indiana; The J. T. Baker Chemical Company of Phillipsburg, New Jersey; The Firestone Tire and Rubber Company of Akron, Ohio; Dr. H. A. B. Dunning of Hynson, Westcott,

and Dunning, Baltimore, Maryland; The Bill Raskob Foundation, Wilmington, Delaware; The Kewaunee Manufacturing Company, Kewaunee, Wisconsin; Francis P. Garvan, New York, New York; Brown Company, Portland, Maine; Brown Company, Berlin, New Hampshire.

In the training of these selected men, fundamental courses in mathematics, physics and English, as well as the four major branches of chemistry (inorganic, organic, physical, and analytical), will be emphasized. There will be no attempt to specialize in the various applications of chemistry. The elective system of study for the student is under an advisory committee of the Department.

An explorative opportunity will be offered in the teaching of chemistry and in industrial work to determine the line of work for which the student is best fitted.

Those who choose teaching as a profession will have the opportunity of taking four subjects in addition to the regular curriculum for a Ph.D. degree in chemistry. The subjects are: Educational Psychology, Philosophy of Education (or History of Education), Theory and Practice in Chemical Education, and Comparative Study of Chemical Development. These subjects will be presented with a view to fitting the candidate to teach in colleges or universities. The satisfactory completion of these subjects will be rewarded by a certificate, which will be given in addition to the Ph.D. degree in chemistry.

As well as pursuing the fundamental curriculum above outlined, the students will have the opportunity of coming into personal contact with leading European and American chemists through a series of special lectures, means for which have been provided by Dr. A. R. L. Dohme of Sharpe and Dohme, Baltimore, Maryland.

Summer Courses in School of Education

In addition to the work in the Faculty of Philosophy, summer courses in Chemical Education are being worked out with a view to applicability to all phases of chemistry, including high schools, colleges, universities, and industries. A few of these courses are listed below. Those starred will be offered in the summer of 1929. Any others listed will be given if there are sufficient applicants for them before May 1st. Earlier applications will be highly appreciated. All applicants will be notified on May 15th whether or not tentative courses which they have elected are to be presented.

1. **Chemical Education.***—This course will cover theory, observation, and practice in the teaching of chemistry. It is especially designed for students who are planning to teach chemistry in universities, colleges, or large high schools.

2. Comparative Study of Chemical Development.*—This course will follow the development of chemistry in both Europe and America, with special attention to the comparative values of the various theories and their interlocking in the advancement of chemistry. Emphasis will be given to the personalities connected with the various developments.

3. Recent Advancements in Chemistry.*—This course will cover those phases of chemistry in which the most recent progress has been made. On certain topics the lectures will be given by specialists in the respective fields covered.

4. Chemistry in America.—This course will endeavor to show the part America has played in the development of chemistry. The lives of those men who have made the greatest contributions to America's chemical development will be stressed.

5. The Influence of Environment on Early Chemistry.—This course will aim to give the student an understanding of the political, economic, social, and philosophical theories which exerted the greatest influence on the origin and early development of chemistry.

6. Chemistry and the World War.—Study of the influence of chemical factors in the European political movements which led to the World War. The part played by chemistry in the World War and the development of the science during the war period. Post-war developments attributable to war-time impetus. Some consideration of probable relations of chemistry to the prevention, occurrence, and prosecution of future wars.

7. History of Chemical Economics.—Interrelations between the development of chemistry and the economic results of such development. Influence of chemical industrial evolution upon the political and economic histories of nations.

8. Contemporary Chemistry Teachers.—Some of the great teachers of chemistry will be studied with special attention to their personalities, methods of presentation, mental habits and attitudes; their intellectual culture and preparation; types of lessons and sources of material for them; selection and use of current literature. Methods of illustration and sources of illustrative material; lecture delivery.

9. The Preparation and Delivery of Lectures.—A study of the technic of preparing lectures, followed by a study of effective methods of delivery and practice in teaching. Educational principles as they affect the audience. There will be personal criticism of content, style, and delivery.

10. Chemical Literature in Teaching.—How to study the current chemical journals to secure new material for courses, and to stimulate the imagination in teaching and research. Reading and interpretation of representative masterpieces and studies in biography for use in teaching.

11. The Teaching Value of Chemical History.—A study of the expansion of chemistry in ancient and modern times, the development of chemical institutions and the growth of chemical ideas and ideals with special reference to the use which the teacher may make of such material in the presentation of general chemistry to students.

12. Tests and Measures in Chemical Education.—The place of tests and measures in chemical education. Measurable results in chemical education. The development of new tests and measures for chemical education.

13. Psychology of Chemical Education.—A study of the educational psychology of the adolescent period, with reference to its specific application in attaining the objectives of elementary chemical instruction.

14. Content and Organization of Chemical Curricula.—Principles involved; types of material; critical and constructive evaluation of the courses now commonly used in high schools, colleges, and universities.

15. Advanced Principles of Chemical Education.—In this course there will be a study of theories with special attention to those factors which support a dynamic theory of chemical education.

16. Contemporary Industrial Chemists.—A study of American and European industrial chemists who have distinguished themselves for their unique leadership. Their personalities and public addresses, inventions, and scientific publications.

17. Patents.—The requirements of a good patent. Procedure in applying for patents. When a patent should be used. How to defend a patent.

18. History of Chemical Industries in the United States.—A critical study of the development of chemical industries in the United States, with special reference to the economic development of the country.

19. Future Development of Chemical Industries in the United States.—The United States will be studied from the standpoint of its undeveloped chemical resources, and the problems which are to be solved before these chemical developments can take place.

20. Chemistry in Countries Other than the United States.—European and other foreign countries will be studied from the standpoint of the influence of their chemical development on the chemistry of the United States.

21. Chemistry in Medicine, Health, and Disease.—A survey of those discoveries which have done most for the advancement of medicine, and a critical analysis of the chemical problems which now stand in the way of further medical development.

22. Chemistry in Agriculture.—A survey of the applications of chemistry to agriculture with a view to determining in what ways chemistry can be applied to the solution of existent agriculture problems.

23. Seminar.—Discussion of research problems in chemical education.

THE CONTRIBUTION OF THE LIBERAL ARTS COLLEGE TO THE GRADUATE CHEMISTRY COURSES OF THE UNIVERSITY OF ILLINOIS*

HARRY F. LEWIS, OHIO WESLEYAN UNIVERSITY, DELAWARE, OHIO

Much speculation has been indulged in regarding the actual contribution of the liberal arts college to the graduate schools of the country, especially in the field of natural science.

A recent publication of the University of Illinois, *Bulletin* 52 of Volume XXIV, Special Circular of the Department of Chemistry, issued August 30, 1927, has made it possible to determine in a practical manner the contribution of such colleges to the graduate courses in the department of chemistry of that university. This bulletin is a complete history of the Illinois chemistry department and lists, among other things, the names and undergraduate history of all those who have gained degrees in chemistry from the University. A study of these data has been used to determine the source of the undergraduate training of all the successful candidates for the Ph.D. degree.

TABLE I

UNDERGRADUATE HISTORY OF 174 SUCCESSFUL CANDIDATES FOR THE PH.D. DEGREE IN THE CHEMISTRY DEPARTMENT OF THE UNIVERSITY OF ILLINOIS, 1903–1926, INCLUSIVE

Total degrees (Ph.D.) conferred from 1903–1926	174	
First period, 1903–1915	31	17.7%
Second period, 1916–1926	143	82.3
Undergraduate schools represented	81	
First period	23	
Second period	70	
Duplicates	12	
First period, universities	10	43.5%
Liberal arts colleges	13	56.5
Second period, universities	28	40.0%
Liberal arts colleges	42	60.0
Degrees conferred	174	
First period, university graduates	16	
College graduates	15	
Second period, university graduates	71	
College graduates	72	
Total of university graduates	87	
Total of college graduates	87	

During the period of years from 1873 until 1926, one hundred and seventy-four Ph.D.'s have been conferred. Since the first in 1903 the yearly number has slowly risen until in 1915 five were granted, making a total of thirty-one for the entire period. With the beginning of the World

* Delivered before the Division of Chemical Education of the A. C. S. at St. Louis, April 17, 1928.

War, a new interest in chemistry was manifest. A glance at Chart I will show a great interest in such degrees during 1916–1917–1918, and a total of one hundred and forty-three degrees during the eleven-year period of

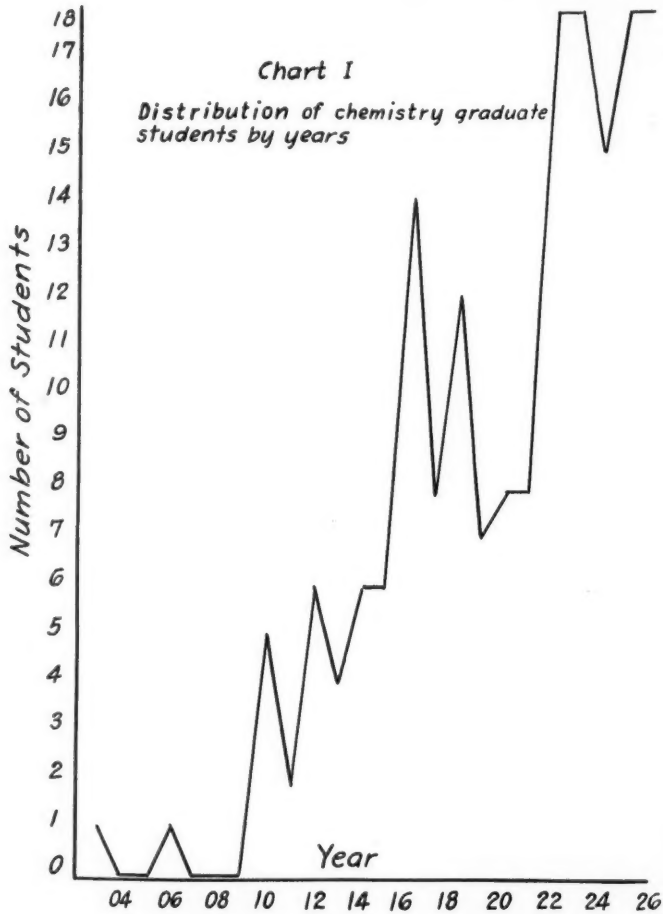


CHART I

1916–1926 inclusive. The high points were reached during 1923, 1925, and 1926, when eighteen such degrees a year were conferred.

These figures have been plotted in Chart I which indicates clearly the general tendency. The sudden increase in numbers during 1916–1919 is followed by a sharp drop during the years 1920–1921 and 1922; this in turn

TABLE II

COLLEGES AND UNIVERSITIES REPRESENTED BY THE ONE HUNDRED AND SEVENTY-FOUR GRADUATE STUDENTS

Name of Institution	Number
Liberal arts colleges	
Baker	1
Baldwin-Wallace	1
Bates	1
Beloit	1
Bucknell	1
Carthage	1
Colgate	1
Creighton	1
Denver	4
DePauw	2
Drake	1
Drury	3
Earlham	1
Eureka	3
Fisk	1
Georgetown College	1
Greenville	2
Crinnell	4
Hanover	1
Hope	7
Howard	1
Illinois College	1
Illinois Wesleyan	2
Iowa State Teachers' College	1
James Millikan	1
Kansas Manual Training Normal	1
Lake Forest	1
Lawrence	1
McMaster	8
Miami	3
Michigan Normal College	1
Monmouth	1
Morningside	3
Mount Holyoke	1
Northwestern College	3
Oberlin	3
Otterbein	1
Rochester	1
St. Procopius	1
Shurtleff	1
Simpson	1
Southern Methodist	2
Southern	1
Tarkio	1
Vassar	2
Wabash	2
Wesleyan	2
Western Reserve	1
Whitman	1
Total	87
Universities	
Alberta	1
British Columbia	1
Cape of Cood Hope	2
Cape Town	1
Chicago	3
College of the City of N. Y.	1
Colorado	2
Idaho	2
Illinois	31
Iowa State College	1
Iowa	2
Kansas	2
Kansas Agricultural College	1
Leland Stanford	1
Michigan	2
Missouri	1
Montana	2
Nebraska	1
New Hampshire	1
Ohio State	1
Oklahoma	3
Oregon State Agricultural College	3
Pennsylvania	1
Pennsylvania State College	3
Pittsburgh	1
Syracuse	1
Texas	1
Utah	1
Washington (St. Louis)	6
Washington (State)	3
Wisconsin	3
Worcester Polytechnic Institute	2
Total	87

is followed by a sharp increase during the years 1923 to 1926. The drop in 1920 probably represents the influence of the post-war period of industrial

expansion and 1923 begins to reflect the limitation of such activity.

The data in regard to the undergraduate training of the one hundred and seventy-four students are found in Table I.

The figures indicate that a greater relative number of graduates of liberal arts colleges received the Ph.D. during the second period than during the first period.

These figures are even more significant when the number of Illinois undergraduates are removed from the list. These number four during the first period and twenty-seven during the second and when this number is subtracted from the total, there remain but twelve university trained men during the first period and forty-four during the second.

This large number of students who have had their early chemical training in the liberal arts colleges suggests that such students have not been unnecessarily handicapped by the nature of their undergraduate training. The fact that eighty-one universities and colleges are represented among the successful candidates indicates that the achievement of the degree depends upon the individual rather than upon the nature of the undergraduate courses taken. Among this large number of schools the courses are bound to vary to a considerable degree both in content and method, and all types of laboratory conditions will be represented.

A list of colleges and universities represented among these one hundred and seventy-four men and women is given in Table II.

Chemicals in Cars Injure Watermelons. Chemical fertilizers are fine for watermelons in the field but "heap bad medicine" for them in freight cars on the way to market. Many luscious melons that might otherwise reach the ultimate consumer are spoiled in transit because they are shipped in cars that have previously been used for hauling chemicals of various kinds, including fertilizers for the melon patches themselves, W. W. Gilbert and F. C. Meier of the U. S. Department of Agriculture told members of the American Phytopathological Society recently.

If melons have to be shipped in cars containing waste chemicals, the two investigators recommend that a good bedding of straw be provided for them. Above all, the car must be kept dry. Moisture permits the chemicals to penetrate the straw bedding and reach the rinds of the melons.—*Science Service*

Benzoate Preservative Depends on Acidity. Benzoate of soda, widely used as a food preservative and often the subject of bitter controversy, depends for its effectiveness on the acidity or alkalinity of the foodstuff to which it is added to prevent spoilage. Prof. W. V. Cruess of the University of California recently reported to the American Society of Plant Physiologists a series of experiments he made, showing that the conventional one-tenth of one per cent is not always sufficient, and that sometimes it is more than enough.

In media that were somewhat acid, represented on the chemist's scale as "pH 2 to 3.5," less than six hundredths of one per cent of sodium benzoate sufficed to prevent the growth of moulds, yeasts, and acid-tolerant bacteria. Around the neutral point, however, as well as over into the slightly alkaline side of the balance, concentrations in excess of one and one-half per cent were necessary to inhibit growth.—*Science Service*

DIFFERENTIATION OF CHEMISTRY COURSE FOR VARIATIONS OF LEARNING CAPACITIES OF PUPILS

RUFUS D. REED, CLARENCE SALTER, CHARLES J. KLUCKHOLM, AND T. P. GIES, LAKEWOOD HIGH SCHOOL, LAKEWOOD, OHIO

Recognizing that students learn at different rates, the office grouped the students of the chemistry classes according to intelligence tests and teachers' marks into fast, medium, and slow classes. In order to adjust the chemistry course to the abilities of students of these different groups, an investigation of the subject matter each group could achieve was made.

The investigation showed:

1. While one cannot predict from the index of brightness alone whether a student will succeed in chemistry, yet when groups of students are considered, there is a correlation between index of brightness and achievement in chemistry.

2. The student with high index of brightness can achieve the traditional chemistry course.

3. Students of low index of brightness have difficulty in accomplishing tasks requiring more than one step.

4. Students of low index of brightness do not retain information of things not used by themselves or their acquaintances.

Procedure

For a semester all groups of one teacher were given as nearly as possible the same instruction. Short tests, taken from Powers "A Diagnostic Study of the Subject Matter of High-School Chemistry," were given without warning to determine whether a knowledge of subject matter taught had been gained. All items of the test had been given in class instruction. At the end of the semester a final test, Powers "General Chemistry Test" Form *B*, was given to all the students. The students' *IB*'s were looked up,

TABLE I

COMPARISON OF ABILITY TO DO CHEMICAL TASKS TO THE *IB*'S OF STUDENTS

	Nature of questions	No. of questions	Average per cent correct answers: *IB* 140–194	cases	*IB* 120–139	cases	*IB* 99–110	cases	*IB* 67–98	cases
1.	Writing formulas, given valence	9	100.0	11	90.1	18	96.8	14	77.4	30
2.	Formulas for names	20	73.8	13	73.7	19	59.3	14	47.8	32
3.	Names for formulas	20	82.2	13	88.9	19	81.9	13	64.2	32
4.	Completing equations	24	62.1	13	52.4	19	41.6	14	24.4	30
5.	Uses from common name	40	86.7	13	80.8	19	74.6	14	72.0	32
6.	Classify as element, compound, or mixture from common name	40	89.8	13	84.7	19	74.8	14	71.4	32
7.	Placing metals in activity series	12	94.0	14	88.4	18	76.4	12	65.2	32
8.	Biography	14	77.0	14	71.8	18	67.0	13	61.7	32
9.	Average all tests		83.2		78.85		71.45		60.51	

the students grouped, and the results tabulated. The results of the tests given during the semester are given in Table I.

Discussion

All these cases were under the same teacher. In every test the achievement of the slowest group was less than the quicker learning groups, which indicated that they learned all types of facts more slowly than the quicker learning groups. In test No. 1 only did the third group achieve more than the second group. Both groups averaged over 90% correct answers. In test No. 3, giving names for formulas, all three higher groups were about the same with the second group having the higher grade by 6%. This indicated that there is excellent correlation between learning rate and ability to achieve in chemistry. These variations would probably disappear if larger numbers of students had been tested. Comparison of the average group grades showed that the higher the *IB* the better the student achieves the work.

Inspection of the work of the students of highest *IB*'s (140–194) showed that in all the work, these students achieved well. The poorest work was in completing equations (62%). This test was answered poorly by all groups. Inspection of the grades of the highest two groups showed that in no test did the average grade fall below 50%. In the third group (*IB*: 99–110) the grade was below 50% in but one case—completing equations. In the lowest group the average grade fell below 50% in two cases—giving formulas for names and completing equations. Both these tasks are ones requiring more than one step in thinking.

Range of Scores on Powers' General Chemistry Test, Form *B*

To gain an idea of the median score and range of scores of students of varying *IB*'s, the scores on Powers' Form *B* test were tabulated. The results were taken from all classes in chemistry after 37 weeks of instruction. The results appear in Table II.

TABLE II

COMPARISON OF STUDENTS' *IB*'S WITH TEST SCORES ON POWERS' FORM *B* CHEMISTRY TEST

Total cases 194. Each group has 39 cases except fourth group, which has 38 cases. Test given after 37 weeks of chemistry

		(Part I 30 ques.)		(Part II 37 ques.)		Entire test range	
Group	Range of *IB*	Range of scores	median	Range scores	median	Range scores	median
First 20%	140–194	13–27	20	5–33	19	19–60	39
Second 20%	128–139	9–25	18	3–24	15	14–48	31
Third 20%	112–127	11–24	18	1–31	16	14–53	32
Fourth 20%	98–111	10–23	16	1–31	8	12–38	24
Fifth 20%	67–98	9–22	16	2–17	9	15–38	24

Discussion

Most of the first fifth were in fast classes and most of the lower fifth were in slow classes. Most of the middle three-fifths were in average classes. A few of second and fourth groups were placed in upper or lower groups. Comparison of ranges of scores showed a wide variation of scores. A comparison of medians showed that the first fifth achieved more than any other group and that the slow fifth achieved in slow classes about as much as the next higher group. This is an argument for the segregated classes where students compete with their equals. The highest total score of the lowest fifth was one less than the median total score of the highest fifth.

Analysis of Achievement of Students of Varying *IB*'s on Powers' Form *B* Test

The tabulation of these results was made to secure results from a larger group of students. The number of questions of each kind was smaller. Powers' results from 700 or 800 cases in unsegregated classes are given for comparison. The results appear in Table III.

TABLE III

COMPARISON OF ACHIEVEMENT ON CHEMICAL TASKS OF GROUPS OF STUDENTS GROUPED ACCORDING TO *IB*

Number of students in each group 39, except group 4 which has 38. Figures give per cent correct answers. *IB* from Otis Test

Nature of task	Powers' results	Our results *IB* 140–194 Group 1	127–139 Group 2	112–127 Group 3	98–111 Group 4	67–98 Group 5
Chemical composition *A*	50.9	69.5	61.2	65.8	54.1	56.9
Chemical composition *B*	68.0	68.6	50.6	54.5	38.1	44.2
Chemical composition *C*	19.9	23.7	17.2	17.9	12.5	11.5
Chemical changes	36.8	50.4	50.0	53.4	50.4	41.9
Names for formulas	25.95	45.5	25.6	25.0	15.8	9.8
Formulas for names	57.5	73.1	51.9	56.4	28.2	21.1
Definitions	68.1	93.8	82.8	80.9	80.1	63.7
Formulas, given valence	..	92.9	77.6	72.4	47.9	69.8
Completing equations	78.1	90.6	82.9	85.6	62.3	39.8
Writing entire equations	31.75	33.7	16.8	21.6	12.0	5.2
Numerical ratio calculations	50.3	38.8	23.8	27.5	13.5	9.9

Discussion

A comparison of Powers' results to ours showed that the fast group excelled Powers' results in every case except in numerical ratios and calculations. The wording of this work was different from that which we had used in our instruction. The slow group excelled Powers' students in but two types of work.

Chemical Composition *A* questions were multiple choice sentence-completion tests—"Plaster of Paris is a compound containing—sodium, potassium, calcium, magnesium, barium." Chemical Composition *B* was composed of questions like: "Write the chemical name for the substance of which charcoal is composed." Chemical Composition *C* was the same as *B*, but dealt with substances that students had little reason to learn or remember the composition of, as water gas, etc. Chemical changes were multiple choice questions.

It is apparent that the ability to write names for formulas is not easily developed. In no case was a group score of 50 per cent made. The substances given to write the formulas for were: methyl alcohol, potassium dichromate, potassium permanganate, and potassium chlorite. The slow students fell down badly on this.

Definitions were easy for all groups. Writing entire equations which required four steps was missed badly by all groups. But the slow group did hardly anything on these questions. They were also much lower than the other groups on completing equations which is a three-step problem. But on writing formulas when given the valence, this group was very efficient as compared to the next higher group. This work is a one-step operation.

A study of the last column showed that it was futile to expend time on the slow classes to drill in knowledge of chemical composition, names for formulas, formulas for names, writing entire equations, or working numerical ratios and calculations.

A study of the fast group 1 results showed that the fast group can achieve better than the average on almost all types of chemical tasks.

Modification of Course of Study in Chemistry for the Various Groups

Accepting the results of this investigation, the following modifications of the Lakewood High School chemistry course were made:

1. For *Fast Classes:* The regular test work. In addition much drill work was done on problems, writing equations, completing equations, writing formulas for chemical compounds. Some comprehensive examination questions in chemistry are used. Four outside reports are required for the second semester. These reports are upon such topics as: the glass industry, paper making, iron and steel, the cultural value of silica, the chemistry of scenery, etc.

2. For *Average Classes:* The regular test work is prescribed. About one outside report a semester is required. The problems at the end of the chapters are worked. The same laboratory work is required of both groups.

3. For *Slow Classes:* The regular text work is required. But most of the involved operations of chemical arithmetic requiring several steps and writing entire equations is but little stressed. Formulas of the common things as sand, water, sulfuric acid, lye, etc., are required. These things are

met with either in the laboratory or in life. The course is made as practical as possible. Emphasis is placed on such things as purification of water, softening of water, combustion, iron and steel, etc., rather than on preparation for higher chemistry.

It is realized that this differentiation is based on the ability of the students of various learning abilities to achieve the results under the present method of instruction. It is assumed that students of low IB do not go to college in numbers, while most of the high IB students go to college.

The following questions have not been investigated, but plans are being laid to attack them:

1. What percentage of slow students go to college? What percentage of fast students go to college? If considerable numbers of slow students go to college, then what change in the chemistry course should be made?
2. What modifications in procedure of instruction should be made for the different groups?

Ultraviolet Light Stronger in Country. The amount of ultraviolet light in the country is actually half again as great as in the city. This has been known or suspected in a general way for some time, but now scientific proof of it has been made by J. H. Shrader, M. H. Coblentz, and F. A. Korff, working at the Baltimore department of Health. The figure reported is the result of actual measurements based on chemical tests. They were made in the center of the city, in nearby suburbs located about three miles from the city's center, and in the country on farms ten miles from the municipal center.

Measurements of the amounts of dust polluting the air were made at the same spots. These showed that air pollution affects the amount of ultraviolet light. The pollution was heaviest in the city and diminished to a figure about one-sixth as great in the country. The amount of dust settled on the top of skyscrapers was less than the amount at the street level, and the amount of ultraviolet light on the top of the buildings was greater than that at street level.

The kinds of dust polluting the air were examined. Carbon, in the form of tarry products, kept out more of the ultraviolet light than ordinary dust or street sweepings.—*Science Service*

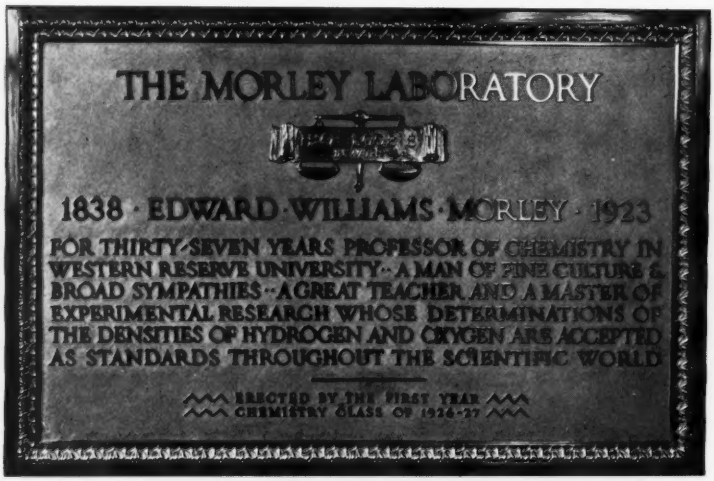
Drugs Need Protection from Light Rays. Light which is so helpful to sick persons does not do their medicines any good. In fact so many of these deteriorate upon exposure to light that druggists have authorized a special study to discover containers which will protect their medicines and chemicals from the harmful light. The plans of the committee which is undertaking the study were reported recently to the American Association for the Advancement of Science by H. V. Arny of Columbia University, head of the committee which was formed by the American Pharmaceutical Association.

In some cases light rays seem to preserve the medical virtues of a preparation, but in others they are definitely harmful. The changes which patients notice in the colors of medicines is usually indicative of change in the medical properties. The following are among the changes, said Dr. Arny. The green color of some iron preparations changes to an unpleasant brown. Bright yellow ointments turn brown or green. Tinctures and fluid extracts made from vegetable drugs turn a dark color and deposit sediments. Serums and other biological products lose their ability to cure or prevent disease.—*Science Service*

MEMORIALS IN CHEMISTRY LABORATORIES

WM. LLOYD EVANS AND JESSE E. DAY, THE OHIO STATE UNIVERSITY, COLUMBUS, OHIO

The various rooms devoted to first-year work in the new laboratory of chemistry at The Ohio State University are identified numerically in conformity with the custom universally used. Two years ago a friend of the Department of Chemistry made a very interesting suggestion to the effect that this traditional method of designating rooms might be discarded for the larger or general student laboratories and that these rooms might well be named in honor of the men and women who have contributed to the fundamental concepts in the science of chemistry. It is quite obvious that


THE MORLEY LABORATORY
1838 · EDWARD · WILLIAMS · MORLEY · 1923
FOR THIRTY-SEVEN YEARS PROFESSOR OF CHEMISTRY IN WESTERN RESERVE UNIVERSITY -- A MAN OF FINE CULTURE & BROAD SYMPATHIES -- A GREAT TEACHER AND A MASTER OF EXPERIMENTAL RESEARCH WHOSE DETERMINATIONS OF THE DENSITIES OF HYDROGEN AND OXYGEN ARE ACCEPTED AS STANDARDS THROUGHOUT THE SCIENTIFIC WORLD
ERECTED BY THE FIRST YEAR CHEMISTRY CLASS OF 1926-27

the numerical system has a directional value which cannot be ignored, particularly, in a large building having an intricate system of corridors.

Be this as it may, this inspiring suggestion was put in possession of the first-year classes of 1926–27 with the gratifying results that the University, through the Department of Chemistry, was presented with sufficient funds for the designing, casting, and erection of the tablet shown in the accompanying cut.* The choice of scientists to be thus honored was left to a ballot selection by the class from a list of thirteen names. As a result of their vote one of the seven laboratories devoted to first-year chemistry will be known henceforth as The Morley Laboratory in honor of Edward Williams Morley.

*This tablet was designed by Professor Thomas Ewing French, professor of engineering drawing, The Ohio State University.

The first-year chemistry class of 1927–28 has since made a similar contribution to the Department—their choice being Joseph Priestley. It is our hope that each of the remaining laboratories will contain similar dignified memorials and that the presence of these tablets and the daily designation of these rooms by the names of certain founders of the science of chemistry will bring home to the first-year students an appreciation of the importance of the great labors of those workers who have made fundamental contributions to this field of human knowledge.

Carbon Monoxide Has No Effect on Mind. Carbon monoxide, deadly gas that gives its victims no warning, is fatal in large amounts but in small amounts it has no harmful effects on the health or mind of the persons exposed to it, even for indefinite periods of time. Two parts or less of carbon monoxide in 10,000 parts of air is considered a safe amount.

The Bureau of Mines and the U. S. Public Health Service have just completed a study of the effects of this gas, both physical and mental, on healthy individuals. A report of the study will be issued shortly. Six persons who had been examined by competent physicians and pronounced in good physical and mental health were exposed to carbon monoxide in concentration of from 1 to 4 parts in 10,000 for 4 to 7 hours every day for 68 days. They were examined frequently during the test and at its finish by physicians and psychologists. The subjects remained in good health and showed no lack of appetite, no change in weight, and no muscular weakness during or after the test. No harmful effects on the mind of the subjects were discovered by the psychologists.

When the concentration of the carbon monoxide was 2 parts per 10,000, half of the people showed no symptoms of carbon monoxide poisoning, such as headache, dizziness, or faintness, no matter how long they were exposed. A few at this concentration had headache after three and one-half to four hours' exposure. However, when the concentration was raised to 3 parts per 10,000, over half the subjects had distinct symptoms in five hours. Almost all of the people tested showed symptoms within three and one-half or four hours when the concentration was 4 parts per 10,000.

No harmful effects on the minds of the subjects could be found by means of psychological tests now known. If there are any such effects from prolonged exposure to carbon monoxide, we need more delicate tests to discover them, reported R. M. Dorcus of Johns Hopkins University and G. E. Wagon of the Mellon Institute who made the psychological tests.

The source of carbon monoxide in this investigation was the exhaust of a gasoline engine. The test showed, among other things, that any ill effects felt by traffic officers in the Holland Tunnel, between New York and New Jersey, are not due to carbon monoxide. The concentration of the gas in the tunnel is kept much lower than the lowest used in the tests.—*Science Service*

Education—A debt due from present to future generations.—*George Peabody*

A LECTURE OR LABORATORY DEMONSTRATION OF COLLOID CATAPHORESIS

WILLARD H. MADSON AND FRANCIS C. KRAUSKOPF, UNIVERSITY OF WISCONSIN, MADISON, WISCONSIN

When subjected to the influence of a difference of potential, particles of certain colloids travel toward the negative pole, the particles of others toward the positive pole. This phenomenon is given as evidence that the colloid carries either a positive or negative charge and is attracted to the pole of opposite charge. As the particles of the colloid reach the oppositely charged pole their charges are neutralized with the accompanying coagulation of the sol about the electrode.

This migration and coagulation is often so slow as to require hours or even days to show a marked change in appearance. While making a study of some of the properties of a beryllium oxide sol, it was noticed that this migration and coagulation was so rapid that a marked change in appearance was evident within an hour or two, and by the end of 12–24 hours the sol was almost completely coagulated around the negative pole. The liquid around the positive pole became at the same time clear and completely free from colloidal matter.

Preparation of the Sol

The following method can be used to prepare the beryllium oxide sol. Three to five cc. of water are added to about one gram of beryllium carbonate (Eimer & Amend C.P.) contained in a small beaker. The carbonate is then dissolved by adding the least possible amount of concentrated hydrochloric acid.

After the beryllium salt has completely dissolved, the solution is carefully evaporated over a very small Bunsen flame (not over 2 cm. high). The basic chloride thus formed is heated until perfectly dry and immediately (without removing the flame) 50 cc. of rapidly boiling water is added and the whole boiled for 1–2 minutes. The boiling colloidal suspension is then quickly poured into a 250-cc. Erlenmeyer flask containing 50 cc. of boiling water and all boiled vigorously for 3–5 minutes. The sol, after this boiling, is quickly cooled by immersing the flask as completely as possible in ice water. When cold the sol is filtered or allowed to stand for a day and then decanted. A portion of the basic chloride is not changed to the colloidal oxide but remains as a residue. The sol should have a very distinct opalescent or milky appearance.

In order to obtain the best sol for this demonstration the heating and drying of the basic chloride should be done very carefully according to the foregoing directions. Otherwise, a very dilute or unstable sol will result. More dilute sols can be made by using larger volumes of boiling water.

These give similar results but the migration and coagulation are not as easily seen from a distance.

Demonstration of Cataphoresis

In each arm of an ordinary five inch U-tube is suspended an electrode made of platinum foil. (The photograph shows these sealed into the side arms with sealing wax but this is not necessary.) The tube is then filled with the sol until the electrodes are about one-fifth covered and the apparatus loosely corked to keep out any dust. A difference of potential of twenty volts is impressed through the sol until the desired amount of coagulation and migration is obtained which usually takes from 3–5 hours. The beryllium oxide collects about the negative pole as a white coagulum, while the liquid about the positive pole becomes perfectly clear. Between these two some of the original beryllium oxide sol remains. The divisions of clear liquid, beryllium sol, and coagulated oxide are very sharp and do not shade into one another at all. After the current is turned off these divisions will remain distinct and sharp for more than a week providing the tube is not jarred.

Figure 1 is a photograph of a tube in which such a demonstration was carried out. The current was allowed to pass through the sol for three hours, after which the photograph was taken. The construction of the tube, divisions of liquid, sol, and coagulated oxide are easily seen.

The study of the properties of beryllium oxide sols is being continued by the authors.

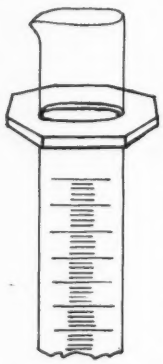
Show Movies of Living Cells at X-Ray Society Meeting. A moving picture of living tissues, showing just what happens to the cells of the body and to cancer cells when radium is applied, was shown at the recent meeting of the American Roentgen Ray Society at Kansas City, Mo. The film, shown by Dr. A. H. Pirie of Montreal, President of the Society, was made by Dr. H. G. Canti of London. In addition, films from the International Radiological Congress at Stockholm, taken by Dr. T. Leucutia of Detroit, were shown.—*Science Service*

A PROTECTOR FOR GRADUATED CYLINDERS

WM. A. ALBRECHT, UNIVERSITY OF MISSOURI, COLUMBIA, MISSOURI

Fatalities to chemical glassware are numerous in many laboratories of instruction, but are especially pronounced in classes of students gaining their first experience in laboratory manipulation. This may be due occasionally to some weakness or irregularity in the makeup of the glass apparatus, in spite of the fact that modern glassware represents a high degree of uniformity in manufacture and withstands breakage very well through special design and composition; but it is due more often to the fact that the beginning student is highly self-conscious of his awkwardness and labors in fear of breakage, both of which lessen his composure and bring on his "bull-in-the-china-closet" behavior.

Wrecked glassware, regardless of its make, seems inevitable, and even good manipulators take such heavy toll that any help in its prevention is desirable. Next to test tubes, laboratory breakage seems to heap itself most abundantly upon the tops of the graduate cylinders. The refuse can collects large numbers of these, in spite of any salvaging efforts to cut them back and to "relip" them, on the part of the parsimonious laboratory instructor with novice glass-working ability. To offset, in part, the extensive breakage in this one item of laboratory equipment, a rubber protector for the cylinder top has been designed and used in this laboratory where graduated cylinders are the most common item of apparatus in several student laboratory exercises. This protector is a simple pentagonal- or hexagonal-shaped rubber neck piece for the graduate, located half way between its lip and upper graduation mark. It may be made from old No. 11 rubber stoppers, by cutting a large hole in the center of a diameter about that of the graduate, trimming the round outer edge into hexagonal shape, and then splitting the stopper horizontally into three pieces.



This neck piece on the graduate prevents not only the breakage of the top when the graduate is knocked over, but keeps the graduate from rolling off the desk which is disastrous, especially in cement-floored laboratories of fire-proof buildings. The protector also facilitates storage of the graduates on the laboratory shelves where they may be racked up in alternate end-to-end order, and handled without breakage in consequence of rolling from the pile.

The cost of this simple addition to the laboratory equipment will be quickly repaid many times through the increased length of service from the cylinders and the saving in the lessened breakage of a relatively costly item.

AMERICAN INSTITUTE OF CHEMISTS AWARDS MEDAL

The American Institute of Chemists will award its medal "for noteworthy and outstanding service to the science of chemistry and the profession of chemist in America" to Mr. and Mrs. Francis P. Garvan, it has been announced.

In making the announcement, Dr. Frederick E. Breithut, the national president of the Institute, said:

Mr. and Mrs. Francis P. Garvan have devoted themselves to the advancement of chemistry in America so whole-souledly and so unselfishly that it is a great pleasure to be able to notify them that the chemists of the country are anxious to show their appreciation and to do them honor. Mr. and Mrs. Garvan have given their time, their money, and, above all, themselves to chemical activities in the governmental, educational, and scientific fields. Mr. Garvan is a sick man, largely as a result of his unsparing efforts in behalf of American chemistry and American chemists. I am happy to be able to state that he now seems on the road to recovery and we hope to have both him and Mrs. Garvan present at our annual meeting on May 4th, when the official award of the medal will be made.

The speakers on that occasion will be Hon. John W. Davis, representing the legal profession; Dr. John J. Abel, of Johns Hopkins, representing the medical profession; and Dr. John H. Finley, representing the general public. Dr. Charles H. Herty will preside and Dr. Finley will make the presentation. Mr. and Mrs. Garvan will respond.

I am also able to announce at this time a fact which has, I believe, never been made public before, and that is, that all contributions and pledges of The Chemical Foundation to chemical education and chemical research, were only made possible by the fact that Mr. and Mrs. Garvan have guaranteed that in the event the Foundation could not meet these pledges, they would personally take care of them. In addition, Mr. and Mrs. Garvan have contributed liberally out of their personal funds to many research activities in which The Chemical Foundation is vitally interested. So much nonsense has been spoken about the enormous profits of the Foundation that I may as well take this occasion to state that not one penny of profit has ever gone to any one connected with the Foundation but that, on the contrary, enormous deficits have been met by Mr. and Mrs. Garvan without a single word of self-seeking publicity.

The work of Mr. and Mrs. Garvan, through their support of The Chemical Foundation, is the most unique and the greatest individual contribution to the fostering of chemical research, chemical education, and the popularization of chemistry in the history of the science. The American Institute of Chemists is proud to show its appreciation through the award of its medal to Mr. and Mrs. Garvan.

The Chemical Foundation was incorporated early in 1919 for the purpose of acquiring by purchase from the Alien Property Custodian, under the provisions of the "Trading with the Enemy Act," a large group of patents, trade-marks, etc. Mr. Francis P. Garvan, formerly Alien Property Custodian, became its first President and still holds that office. Neither the president nor vice president of the corporation can receive compensation. The stock of the corporation is held by 158 stockholders. The common stock is the voting stock, and each stockholder is limited to two shares of the common stock. The preferred stock is redeemable at par under certain conditions, and when redeemed, the return to the stockholder cannot exceed 6% per annum.

The charter of The Foundation provides that it license its patents, trade-marks, and other properties *non-exclusively* to American industry on a royalty basis, and further provides that the profits from such licenses shall be spent for the advancement of chemical and allied science and industry in the United States. Since its inception, The Foundation has granted more than 800 licenses to corporations in practically every industry in the country, and its funds have been spent in the advancement of chemical education and research.

Some five years ago Mr. and Mrs. Garvan, through gifts of their personal funds, inaugurated the Prize Essay Contest which is conducted by the Foundation under the auspices of the American Chemical Society, for all high-school, normal-school, and college chemistry students in the country. This project alone runs to an amount in excess of $50,000 a year from their personal funds.

The Foundation has fostered, in so far as it has been possible, many research activities.

The Chemical Foundation has entirely financed the researches of Dr. Dochez of the Presbyterian Hospital Laboratories for the past several years in his researches on the cause and possible cure of the common cold. The work developed by Dr. Dochez at the Presbyterian Hospital showed the necessity of a much larger effort being made, and The Foundation appropriated $195,000 to Johns Hopkins University to make a concentrated effort by some of the best scientists of the country, headed by Dr. John J. Abel, to try to determine the possible cause and cure of the common cold.

The Foundation entirely financed the Commission on Standardization of Biological Stains. The work done by this Commission has been of tremendous importance to the medical research work of the country. Prior to the war, we were absolutely dependent upon Germany for biological stains. Today, we manufacture in this country stains that are standardized to meet our own needs, and export them to practically every country in the world.

The Foundation has assisted Dr. John W. Churchman at Cornell Medical

School in his work on the uses of aniline dyes in intestinal infections, and has also assisted in financing the work of Dr. Hugh H. Young of Johns Hopkins University on the use of mercurio compounds on internal infections.

The Foundation has appropriated small sums in various states to assist the agricultural colleges and experiment stations for sewage research, which is one of the most important research problems in the country, as a great many diseases emanate from sewage and very little research on this problem has been done. Through the Foundation's efforts in various states, we now have several of them appropriating money for this purpose. A national organization has been formed and a technical magazine covering this field has been published, all of which is being financed by The Foundation. In this particular field, it has been very gratifying to note that the various states and organizations in the states are ready and willing to support this work. The problem was to lay the facts before them.

The Foundation is partially financing the new chemo-medical research laboratories at the New Medical Center in New York City. This is one of the first real chemo-medical research laboratories in this country.

The Foundation has made large contributions to various national organizations to enable them to bring up to date and keep up to date several of the most important scientific publications. It has contributed $275,000 to the American Chemical Society for the purpose of bringing and keeping up to date *Chemical Abstracts*, an important publication to all chemists. In addition, it has contributed several other large amounts to various activities of the American Chemical Society, such as $5000 to help cover its deficit of the Institute of Chemistry; $5000 to the journal of *Industrial and Engineering Chemistry* to enable it to print a large number of scientific articles which they had accumulated and which they did not have sufficient funds to print, and various other such items. It has also contributed to a large number of activities of the National Research Council for specific activities for which the Council did not have the funds. It has financed almost entirely the *Journal of Physical Chemistry*.

The Foundation has also financed all of the deficits of the *Journal of Chemical Education*, which was founded and published principally for the chemistry teacher in order that he might be kept abreast of current developments in chemistry and have up-to-date information on this subject brought to his desk each month. It is, however, interesting to note that many of the subscribers to THIS JOURNAL are industrial chemists and business men.

The Foundation has materially assisted several of the large universities of the country in their efforts to obtain new chemical laboratories and equipment. Some of these universities are Georgetown, Johns Hopkins, Yale, Harvard, Princeton, and Chicago. The Foundation has assisted the International Congress of Soil Science. It has contributed $10,000 toward the completion of International Critical Tables.

In its endeavor to bring the importance of chemistry before the layman in a non-technical way, one of the very first activities of the Foundation was to distribute popularly written chemistry books such as Slosson's "Creative Chemistry" to a large number of the business men and educators of the country, emphasizing the tremendous importance of chemistry to industry, elimination of waste, conservation of national resources, and research in the prevention and cure of disease. In this connection, The Chemical Foundation published several popularly written books, such as "Chemistry in Industry"—two volumes, "Chemistry in Agriculture," and "Chemistry in Medicine," all of which have been widely distributed throughout the United States, and many of which are now used as textbooks in our schools and colleges. In addition to the distribution of this large number of books, the Foundation has distributed hundreds of thousands of copies of various pamphlets, booklets, and other informative literature pertaining to the value of chemistry to all human activities, the total of such distribution being approximately *twenty million* pieces of literature. It is no exaggeration to say that this literature has educated the whole American nation.

Flying Electrons Cause Evolutionary Changes. The mutations, or sudden evolutionary changes, that can be caused by exposing living organisms to x-rays, radium and similar powerful radiations, are probably due to high-speed negatively charged electrons, or beta rays. Such rays are given off directly by radium, and arise as a result of x-ray bombardment of solid matter.

The researches on which this conclusion is based were described recently before the American Society of Zoölogists by Dr. Frank Blair Hanson of Washington University, St. Louis. Dr. Hanson exposed fruit flies to the action of radium, giving different sets of them varying degrees of protection behind thin lead screens. The number of mutations produced varied according to the degree of protection. Then he made measurements of the number of beta particles that got through the same set of screens, and found that these varied in exactly the same numerical proportion as the mutations. In brief, the more intense the beta-ray bombardment, the more frequent the mutations.—*Science Service*

Synthetic Cod-Liver Oil Being Manufactured Now. A new product that has cod-liver oil's ability to build bones and prevent rickets but that is without the offensive taste of the fish oil is now being manufactured by an American firm under the Steenbock patents on irradiated foods. This new kind of "cod-liver oil" is based on the newly discovered fact that a chemical substance, ergosterol, found in the fish oil, is the substance that has the antirachitic power.

Ergosterol is also found, in an inactive state, in yeast and in certain fungi. It has been isolated from ergot oil, found in the fungus on rye which furnishes medicine with another widely used substance, ergot. Exposure to ultraviolet rays, either from the sun or from artificial sources, gives yeast ergosterol the antirachitic properties. This activated yeast ergosterol has been dissolved in peanut and cottonseed oils and is being manufactured and will be sold as a cod-liver oil substitute. The process was worked out by Dr. Charles E. Bills. The new product has the further advantage that it will not spoil and grow rancid as cod-liver oil sometimes does.—*Science Service*

The Chemistry Student

THE STRUCTURE OF MATTER. VI. THE PERIODIC CLASSIFICATION OF THE ELEMENTS COMPLETED

OTTO REINMUTH, ASSOCIATE EDITOR

In the October number[1] we began a discussion of the periodic properties of the elements in the light of our present theories of atomic structure. It is recommended that the reader refresh his memory of that article before proceeding with the present one.

It will be recalled that we began the construction of a periodic table and that the chart facing page 1320 depicted one period of two elements, two periods of eight elements each, and part of a fourth period. It was in the fourth period that we began to encounter difficulties, culminating in the impossibility of fitting iron (atomic number 26) into the eighth column of our table.

The Fourth Period

It is evident that we are entering upon a period longer than eight. If we begin with potassium and count the elements in the order of their atomic numbers until we arrive at krypton, the next noble gas after argon, we find that we have run through a series of eighteen. (See Table I.) How shall we distribute eighteen elements across eight columns and come out even at the end? It is true, of course, that many periodic arrangements of the elements contain more than eight columns. At the outset, however, we have said that the maximum number of electrons which can occupy the valence or outermost shell of any atom is eight. The inclusion of additional columns, therefore, would not get us out of our immediate difficulty.

The ideas which led to a satisfactory solution of the problem arose over a period of time and should be credited to Rydberg, Langmuir, Lewis, and others. Bury[2] finally assembled them, made an important addition or two of his own and offered the simple explanation which we shall now examine. The necessary postulates may be summed up briefly as follows:

1. The maximum and the stable number of electrons for the first "shell" or "layer" outside the nucleus is two.

[1] "The Structure of Matter. II. The Periodic Classification of the Elements," THIS JOURNAL, **5**, 1312–20 (Oct., 1928).

[2] *J. Am. Chem. Soc.*, **43**, 1602 (1921).

TABLE I

ATOMIC NUMBERS

1	Hydrogen	32	Germanium	63	Europium
2	Helium	33	Arsenic	64	Gadolinium
3	Lithium	34	Selenium	65	Terbium
4	Beryllium	35	Bromine	66	Dysprosium
5	Boron	36	Krypton	67	Holmium
6	Carbon	37	Rubidium	68	Erbium
7	Nitrogen	38	Strontium	69	Thulium
8	Oxygen	39	Yttrium	70	Ytterbium
9	Fluorine	40	Zirconium	71	Lutecium
10	Neon	41	Columbium	72	Hafnium
11	Sodium	42	Molybdenum	73	Tantalum
12	Magnesium	43	...	74	Tungsten
13	Aluminum	44	Ruthenium	75	...
14	Silicon	45	Rhodium	76	Osmium
15	Phosphorus	46	Palladium	77	Iridium
16	Sulfur	47	Silver	78	Platinum
17	Chlorine	48	Cadmium	79	Gold
18	Argon	49	Indium	80	Mercury
19	Potassium	50	Tin	81	Thallium
20	Calcium	51	Antimony	82	Lead
21	Scandium	52	Tellurium	83	Bismuth
22	Titanium	53	Iodine	84	Polonium
23	Vanadium	54	Xenon	85	...
24	Chromium	55	Cesium	86	Radon
25	Manganese	56	Barium	87	...
26	Iron	57	Lanthanum	88	Radium
27	Cobalt	58	Cerium	89	Actinium
28	Nickel	59	Praseodymium	90	Thorium
29	Copper	60	Neodymium	91	Protoactinium
30	Zinc	61	Illinium	92	Uranium
31	Gallium	62	Samarium		

2. The maximum and the stable number for the second layer is eight.

3. The third layer can be occupied by a stable group of eight electrons. Except when the third layer is also the valence layer, however, the maximum number of electrons for this shell is eighteen.[3]

4. A fourth layer of electrons may begin to form before the third layer has completed its maximum group of eighteen.

5. Certain elements are able to exist in more than one form. In other words, they are able to transfer electrons from the third to the fourth layer and vice versa.

The last two postulates are very important for they show us how we can

[3] Some chemists prefer to divide the group of eighteen into two or more layers. However, since little is definitely known about the actual spatial arrangement of these electrons, we shall, for the sake of simplicity, adhere to Bury's original scheme.

distribute eighteen elements through eight columns and at the same time they offer an explanation for the behavior of certain elements of variable valence.

Let us begin our fourth period anew. The structures previously presented for potassium, calcium, and scandium need not be altered. For these elements the electron layer arrangements which we may designate as (2, 8, 8,1), (2, 8, 8, 2), and (2, 8, 8, 3), respectively, seem to be quite stable and to account satisfactorily for their chemical behavior. When we come to titanium, however, we find that a transition from the eight-electron to the eighteen-electron third layer is beginning. Titanium exhibits not

TABLE II—THE FOURTH PERIOD

1	2	3	4	5	6	7	8
K 19 (2,8,8,1)	Ca 20 (2,8,8,2)	Sc 21 (2,8,8,3)					
	Ti (2,8,10,2)	Ti (2,8,9,3)	Ti 22 (2,8,8,4)				
	V (2,8,11,2)	V (2,8,10,3)	V (2,8,9,4)	V 23 (2,8,8,5)			
	Cr (2,8,12,2)	Cr (2,8,11,2)			Cr 24 (2,8,8,6)		
	Mn (2,8,13,2)		Mn (2,8,11,4)		Mn (2,8,9,6)	Mn 25 (2,8,8,7)	
	Fe 26 (2,8,14,2)	Fe (2,8,13,3)	Fe (2,8,12,4)		Fe (2,8,10,6)		
	Co (2,8,15,2)	Co 27 (2,8,14,3)	Co (2,8,13,4)				
	Ni (2,8,16,2)	Ni (2,8,15,3)	Ni 28 (2,8,14,4)				
Cu 29 (2,8,18,1)	Cu (2,8,17,2)						
	Zn 30 (2,8,18,2)	Ga 31 (2,8,18,3)	Ge 32 (2,8,18,4)	As 33 (2,8,18,5)	Se 34 (2,8,18,6)	Br 35 (2,8,18,7)	Kr 36 (2,8,18,8)

only the valence of four which we previously attributed to it, but also valences of two and three. The succeeding seven elements also display transition properties, and then, beginning with zinc, we proceed in the normal manner to fill out the period. Table II sets forth structures which Bury proposed to account for the characteristics of the elements of the first "long period."

The Fifth Period

An examination of succeeding elements, preliminary to beginning the fifth period, reveals the fact that this group should be somewhat like the fourth. Beginning at rubidium and counting until we arrive at a noble gas (xenon), we again run through a series of eighteen.[4] A consideration of the chemical properties of these elements, however, shows that we need postulate only three transition members in the series rather than eight as in the previous period. Table III indicates the structures assigned

TABLE III THE FIFTH PERIOD

K-2, L-8, M-18

1	2	3	4	5	6	7	8
37 **Rb**	38 **Sr**	39 **Y**	40 **Zr**	41 **Cb**	42 **Mo**	43—	
N-8	*N-8*	*N-8*	*N-8*	*N-8*	*N-8*		
O-1	*O-2*	*O-3*	*O-4*	*O-5*	*O-6*		
	44 **Ru**	44 Ru	44 Ru		44 Ru		44 Ru
	N-14	*N-13*	*N-12*		*N-10*		*N-8*
	O-2	*O-3*	*O-4*		*O-6*		*O-8*
	45 Rh	45 **Rh**	45 Rh		45 Rh		
	N-15	*N-14*	*N-13*		*N-11*		
	O-2	*O-3*	*O-4*		*O-6*		
	46 Pd	46 Pd	46 **Pd**				
	N-16	*N-15*	*N-14*				
	O-2	*O-3*	*O-4*				
47 **Ag**	48 **Cd**	49 **In**	50 **Sn**	51 **Sb**	52 **Te**	53 **I**	54 **Xe**
N-18	*N-18*	*N-18*	*N-18*	*N-18*	*N-18*	*N-18*	*N-18*
O-1	*O-2*	*O-3*	*O-4*	*O-5*	*O-6*	*O-7*	*O-8*

by Bury to the elements of the fifth group. In order to conserve space we have omitted the first three electron shells of these elements, which contain in every case two, eight, and eighteen electrons, respectively, and have noted only the two outermost layers. The electron layers of atoms are frequently designated by letters, beginning with *K* for the innermost and proceeding outward alphabetically. Thus, for the fifth group we may write:

[4] That is, if we include in our count the blank space left for the supposedly missing element number 43.

K-2
L-8
M-18
N }
O } -as indicated in Table III

The fact that ruthenium extends into the eighth column should not be taken to indicate that it ever acts like a noble gas. This structure is included to account for the tetroxide which may be represented electronically as follows:

The Sixth Period

The sixth period again calls for an extension in length. Thirty-two elements are included in the series from cesium to radon, the last of the noble gases. The additional postulates necessary to account for this fact are:

6. The fourth or *N* electronic layer may be occupied by stable groups of eight, eighteen, or thirty-two electrons. Thirty-two electrons constitute the maximum possible. As before, it is assumed that electrons may be added to outside shells before the stable inner groupings are completed.

7. The fifth or *O* electronic layer may contain stable groups of eight or eighteen electrons. These groupings also may remain incomplete while electrons are added to outer shells. Atoms of variable structure are possible.

We can therefore look for two transition groups in the sixth period. The first will correspond with the change from an *N* layer of eighteen electrons to an *N* layer of thirty-two electrons. This change takes place through fourteen of the rare earths. The second transition is from an *O* layer of eight electrons to an *O* layer of eighteen electrons. It is in most respects similar to the *N* layer transition from eight to eighteen electrons which we noted in the fifth period. Here four elements are involved—osmium, iridium, platinum, and gold.

For several transition members of the rare earth group, Bury postulated variable structures. The remaining members of the series are supposed to vary from each other only by successive additions of one electron to the *N* layer as one proceeds down the list.[5] Bury's structures for these elements may be indicated as follows:

[5] It is understood, of course, that corresponding additions of protons are made to the nucleus. In the present article we have avoided unnecessary complications by ignoring isotopes, although many of the elements discussed are isotopic. If the student so desires, he can refer to the first volume of the "International Critical Tables" and construct for himself isotopic diagrams similar to those shown in the second article of this series. THIS JOURNAL, **5,** 1312–20 (Oct., 1928).

Ce		(2, 8, 18, 19, 8, 3)	(2, 8, 18, 18, 8, 4)
Pr		(2, 8, 18, 20, 8, 3)	(2, 8, 18, 19, 8, 4)
Nd		(2, 8, 18, 21, 8, 3)	
Il		(2, 8, 18, 22, 8, 3)	
Sa	(2, 8, 18, 24, 8, 2)	(2, 8, 18, 23, 8, 3)	
Eu	(2, 8, 18, 25, 8, 2)	(2, 8, 18, 24, 8, 3)	
Gd		(2, 8, 18, 25, 8, 3)	
Tb		(2, 8, 18, 26, 8, 3)	
Ds		(2, 8, 18, 27, 8, 3)	
Ho		(2, 8, 18, 28, 8, 3)	
Er		(2, 8, 18, 29, 8, 3)	
Tm		(2, 8, 18, 30, 8, 3)	
Yb		(2, 8, 18, 31, 8, 3)	
Lu		(2, 8, 18, 32, 8, 3)	

The complete plan for the sixth period (but with the rare earths condensed) is shown in Table IV. Osmium is introduced into the eighth column, not to show any relationship with the noble gases but to account for its tetroxide, as was the case with ruthenium in the fifth period.

TABLE IV THE SIXTH PERIOD

K-2, L-8, M-18

1	2	3	4	5	6	7	8
55 **Cs**	56 **Ba**	57 **La**					
N-18	*N-18*	*N-18*					
O-8	*O-8*	*O-8*					
P-1	*P-2*	*P-2*					
	62, 63	58–71	58, 59				
	Rare	**Rare**	Rare				
	Earths	**Earths**	Earths				
			72 **Hf**	73 **Ta**	74 **W**	75—	
			N-32	*N-32*	*N-32*		
			O-8	*O-8*	*O-8*		
			P-4	*P-5*	*P-6*		
	76 **Os**	76 Os	76 Os		76 Os		76 Os
	N-32	*N-32*	*N-32*		*N-32*		*N-32*
	O-14	*O-13*	*O-12*		*O-10*		*O-8*
	P-2	*P-3*	*P-4*		*P-6*		*P-8*
	77 Ir	77 **Ir**	77 Ir		77 Ir		
	N-32	*N-32*	*N-32*		*N-32*		
	O-15	*O-14*	*O-13*		*O-11*		
	P-2	*P-3*	*P-4*		*P-6*		
	78 Pt	78 Pt	78 **Pt**		78 Pt		
	N-32	*N-32*	*N-32*		*N-32*		
	O-16	*O-15*	*O-14*		*O-12*		
	P-2	*P-3*	*P-4*		*P-6*		
79 **Au**	79 Au	79 Au					
N-32	*N-32*	*N-32*					
O-18	*O-17*	*O-16*					
P-1	*P-2*	*P-3*					
	80 **Hg**	81 **Tl**	82 **Pb**	83 **Bi**	84 **Po**	85—	86 **Rn**
	N-32	*N-32*	*N-32*	*N-32*	*N-32*		*N-32*
	O-18	*O-18*	*O-18*	*O-18*	*O-18*		*O-18*
	P-2	*P-3*	*P-4*	*P-5*	*P-6*		*P-8*

THIS CHART WILL BE THE FIRST CHART
APPEARING AT THE END OF THIS FILM

The Seventh Period

The seventh period is but a fragment and may be easily disposed of in the first six columns of our table. There has been some speculation as to whether this fragment represents the beginning of a new period of eighteen or thirty-two theoretical elements. On the whole, its members seem to resemble most closely the elements occurring in the preceding periods of eighteen. Such speculations need not concern us greatly, however, for it is quite evident that these elements approach, and probably reach in uranium, the ultimate limit of size and complexity compatible with a degree of stability necessary for existence. Even these elements break down spontaneously, giving rise to the phenomenon known as radioactivity.

Periodic Tables, Charts, and Models

Our completed table may be assembled as shown on the folder herewith. Attention to the symbols printed in bold-faced type will reveal that if some means can be found for disposing of the transition members of the rare earth group and the nine other transition elements, iron, cobalt, nickel, ruthenium, rhodium, palladium, osmium, iridium, and platinum, the remaining elements can be arbitrarily distributed in regular series across an eight-column table. In the modern form of Mendeléeff's table the rare earths are condensed (much as we have condensed them) and the other nine elements listed above are placed in a ninth column on the right. Some people prefer an eighteen-column table. The possible forms of tabulation are almost innumerable and nearly every form has some merit which particularly endears it to its maker. Systems which require space models are almost as numerous; most of them are variations of the helix. The table which we have employed here is not recommended for general use; it is not nearly compact enough. We have chosen this form not because of its merits as a periodic chart but because it illustrates clearly the structures of the elements and the reason for the periodicity of their properties. The student will not find it time wasted to arrange a table or model of his own if he is interested in such a project. References to charts and models which have been described in THIS JOURNAL are listed below.

References

1. Geo. W. Sears, "A New Form of Periodic Table as a Practical Means of Correlating the Facts of Chemistry," THIS JOURNAL, **1**, 173–7 (Oct., 1924).

2. M. Courtines, "A Model of the Periodic Table," *Ibid.*, **2**, 107–9 (Feb., 1925).

3. W. H. Rodebush, "A Compact Arrangement of the Periodic Table," *Ibid.*, **2**, 381–3 (May, 1925).

4. H. A. Geaque, "A Classification of the Elements with Respect to Their Properties," *Ibid.*, **2**, 464–6 (June, 1925).

5. Ira D. Garard, "A Simple Rule for the Classification of the Elements," THIS JOURNAL, **3,** 542–6 (May, 1926).

6. C. J. Monroe and W. D. Turner, "A New Periodic Table of the Elements," *Ibid.*, **3,** 1058–65 (Sept., 1926).

7. O. J. Stewart, "Another Attempt to Base a Classification of the Elements on Atomic Structure," *Ibid.*, **5,** 57–63 (Jan., 1928).

Errata

Two errors in previous articles of this series have been called to our attention. On page 1316 of the October number, line eleven, Prout is incorrectly written "Proust." On page 1479 of the November number, line two, tetravalent is incorrectly written "tervalent."

FIRE CONTROL BY PARADOX*

Recent discoveries indicate that we still have much to learn about so familiar a phenomenon as fire. By way of example, we found in our own laboratory not long ago that the insulation of the wires used on telephone switchboards could be flameproofed by applying a dilute suspension of selenium to the braided wire. Since selenium is closely related to sulfur and is itself combustible, its effectiveness in flame suppression is extraordinary, and for it no satisfactory explanation has yet been found.

We are now confronted with another paradox in the recent announcement of Thomas and Hochwalt that solutions of such highly oxidizing agents as potassium nitrate (saltpeter), and even the chlorates and perchlorates of potassium, are far more effective in extinguishing fires, and especially oil fires, than water alone. Here, again, the explanation is still lacking, and for want of better understanding the amazing results are attributed to "catalytic" effect.

In the investigation of this effect, compounds of practically every element capable of forming a water-soluble salt were studied, but with one or more minor exceptions only compounds of the alkali metals appear to possess this "catalytic" effect on combustion. Among these compounds those containing oxygen are the more effective.

Comparative tests demonstrate the startling fact that a solution of such a powerful oxidizing agent as potassium perchlorate is five times as effective as one of potassium chloride and nearly twenty-five times as effective as a solution of common salt.

These discoveries have already received practical application in a new type of portable fire extinguisher.

* From the *Industrial Bulletin* of Arthur D. Little, Inc., July, **1928.**

ASSAYING WITH AGRICOLA*

R. D. BILLINGER, UNIVERSITY OF CINCINNATI, CINCINNATI, OHIO

In our study of the history of chemistry we usually designate the age of Lavoisier (1743–1794) as the beginning of the quantitative period. It was only then that the analytical balance came into general use for quantitative methods of investigation. But there was at least one branch of quantitative analysis which had come to an advanced stage of development in the early 16th century. This was the art of assaying.

Assaying is a branch of analytical chemistry which includes the quantitative estimation of metals in ores and furnace products. It had developed to such a high degree by 1556 that Georgius Agricola, in his treatise *De Re Metallica*,[1] devoted an entire Chapter (Book VII) to methods of assaying ores.

The beginnings of assaying date much earlier. We find references to the use of the touchstone for testing the purity of gold and silver, mentioned by Theophrastus.[2]

Among the alchemists, Geber describes methods of fusing in crucibles, cupellation, and the parting of gold and silver by acid and by sulfur. These were in no sense accurate quantitative methods, but they were the foundations for assaying methods which must have developed gradually as they were handed down through generations from father to son.

In the early 16th century there appeared in German a series of anonymous booklets under the title of *Probierbüchlein*. They consist of a collection of recipes for assaying and include directions for crucible, scorification, and cupellation tests. So far as known they are the first written texts on assaying. As Mr. Hoover says, "these booklets represent the first milestone on the road to quantitative analysis, and in this light they have been largely ignored by the historians of chemistry."

Agricola acknowledges these sources of information and also refers to a work of Vannuccio Biringuccio (*De La Pirotechnia*, Venice, **1540**) in Italian. Biringuccio's book includes several chapters which treat the subject of assaying, but it is mostly devoted to metal working and founding.

* Photographic reproductions by courtesy of Mr. M. Billinger.

[1] The writer has used the excellent English translation of Mr. and Mrs. Herbert C. Hoover. Their work is a noteworthy contribution to the history of science, because the translation has been accomplished by those who are intimately acquainted with the subjects treated. The general style and appearance of the original Latin version have been adhered to; the illustrations being remarkable reproductions. The footnotes which abound throughout the translation give interesting sidelights on the history of various subjects, and clarify the text. Copies of both the Latin and English texts were borrowed from the Library of Lehigh University.

[2] 371–228 B.C. See "On Stones," translated from the Greek by Sir John Hill, **1746**, London.

But all that preceded was a jumble of recipes compared to the orderly arrangement which Agricola compiled. Except for the explanations which follow as a result of the atomic theory, much of our present-day knowledge of assaying is scarcely in advance of that shown in *De Re Metallica*. It is remarkable how slight have been the general advances in assaying since then, and it is a question whether this is a reflection on our modern progress or a tribute to Agricola's advanced thought. Certain it is that he was far ahead of his contemporaries in some of his methods and ideas.

FIGURE 1.—ROUND ASSAY FURNACE

It will not be possible to repeat all of the methods used by Agricola, but only to mention some of the more important items which find a counterpart in modern practice.

After describing the purpose of assaying, Agricola proceeds to explain the requirements—the furnaces, crucibles, fluxes, etc. He very carefully advises the assayer to "close the doors of the room in which the assay furnace stands, lest any one coming at an inopportune moment might disturb his thoughts when they are intent on the work"—a good rule for any analyst.

Figures 1, 2, and 3 show three types of furnaces described by Agricola. The first furnace was made of bricks, while the second or rectangular furnace was formed of iron plates, wired together and smeared with lute. Both furnaces were operated similarly. Charcoal was used as fuel, and a draught was admitted through holes in the furnace bottom to stimulate the fire. A clay furnace of somewhat similar design is described. Muffles of clay were used in the furnaces to cover the scorifiers and prevent coal dust from contaminating the assay.

FIGURE 2.—RECTANGULAR ASSAY FURNACE

In Figure 3 is shown a sort of forge (*circulus*) used for crucible fusions. It consists of an iron hoop placed upon the hearth of a chimney. In this

case a bellows is used to supply the draught. Minute details of construction and operation are given for each furnace. In Book IX, under methods of smelting ores, Agricola shows the use of multiple unit bellows for furnaces, so it is evident that the use of an induced draught must have been quite general.

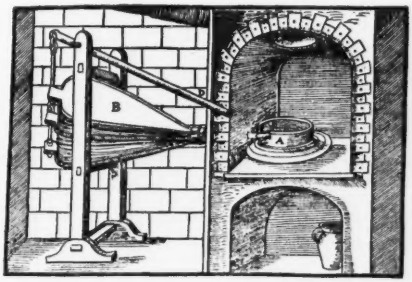


FIGURE 3.—*A*, IRON HOOP; *B*, DOUBLE BELLOWS; *C*, ITS NOZZLE; *D*, LEVER

One of the most striking resemblances to our modern practice is the matter of the shape of crucibles used. In Figure 4 are shown illustrations of Agricola's scorifier, triangular crucible, and cupel. These are almost identical with the shapes now employed. The scorifying dishes and crucibles were made of clay, while the cupels were made of wood or bone ash. In the former "ore mixed with fluxes is melted," while in the cupels "lead is separated from silver, and by them assays are concluded."

Directions are given for preparing ores for assaying by means of roasting, burning, crushing, and washing.

In the matter of fluxes and reagents, Agricola is not so clear. His additions to ore charges include oxidizing and desulfurizing agents, reducing and sulfurizing agents, collecting agents, and fluxes. Of course, he does not employ this nomenclature and it is impossible to read into his directions the modern views of reactions. His mixtures are sometimes hard to reconcile, but this is still a common fault in much more recent books of assaying. The mixtures recommended would perhaps produce the desired result, but many of the reagents would simply duplicate the functions of others. However, the list of reagents used is large and varied, and we find most of the common reagents in use today. Thus argols, pyrites, litharge, saltpeter, soda, borax, lead granules, glass-galls, lime, salt, and "stones which easily melt" (quartz and fluorspar) were commonly used, together with other substances of less familiar character.

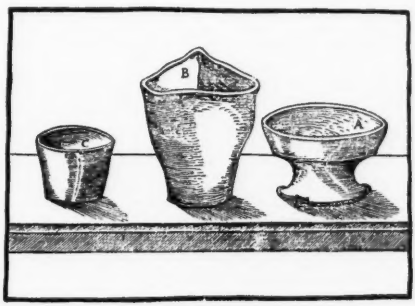


FIGURE 4.—*A*, SCORIFIER; *B*, TRIANGULAR CRUCIBLE; *C*, CUPEL

To decide the proper combination of fluxes for an assay, Agricola made a preliminary heating of the ore and observed the color of the fumes emitted. This gave him some idea of the character of his sample.

Two general methods of assaying ores are described—"one by which the lead is mixed with ore in the scorifier and afterward again separated from it in the cupel; the other by which it is melted in the triangular earthen crucible and afterward mixed with lead in the scorifier, and later separated from it in the cupel." These methods are precisely the ones employed today.

There follow descriptions of methods of assaying ores for gold, silver, copper, lead, tin, bismuth, mercury, and iron. In the gold assay, fire methods are described and there is also given a combination method of washing and amalgamation. In these methods the procedure followed indicates that care was taken to have as high a degree of accuracy as possible in the assay. For example, in the assay of lead ore, Agricola infers that a known ore should be run with the assay, to "take account of that portion of it which the fire has consumed."

In discussing the assay of metal alloys, Agricola describes the use of the touchstone for determining the approximate proportions of gold and silver in rich alloys (bullions). The method consists of comparing the scratch made on a piece of jasper by the unknown alloy with scratches made by needles of known composition. As mentioned before, this method was not new with Agricola, but he amplified it and gave it wide application. Four types of standard needles are mentioned. "The first kind are made of gold and silver, the second of gold and copper, the third of gold, silver, and copper, and the fourth of silver and copper."

The use of the touchstone was much employed for testing gold coins, in preference to the fire methods, for—as Agricola says—"when gold coins are assayed in the fire, of what use are they afterward?" The touchstone method is still employed as an approximate mint method.

In the assay of gold bullion, silver was added to make the total silver content three times the weight of the gold present. This corresponds favorably to our modern ratio of two or two and one-half.

Parting the gold and silver by means of "*aqua valens*" (mostly nitric acid) is described. In Book X a number of other methods of parting are given, chief of which is a method of "cementing." The cement used was either a mixture of saltpeter and vitriol and some aluminous medium or siliceous material; or a paste of common salt and a similar medium. The process consisted in subjecting a mixture of finely divided bullion and cement to long heating at a temperature under the melting point of the alloy.

Agricola used two systems of weights known as the "greater weights" and the "lesser weights," and by arranging each system with similar units

he had a method of proportionate weights which was much simpler than our modern "assay ton" system. Our system with its unit of one assay ton (29.166 grams) is so arranged that when determinations are weighed in milligrams, the result will tell us directly the number of Troy ounces of precious metal per ton of ore. Agricola's method employs 100 units (*librae*) in the standard of weight (the *centumpondium*), and if, for example, an ore contained one *libra* of gold to the *centumpondium*, it would contain $^1/_{100}$th part, no matter what the actual weight of the units of the "lesser weight" might be. Agricola explains it thus—"Whatsoever small amount of metal is obtained from a *centumpondium* of the lesser weights of ore or metal alloy, the same greater weight of metal is smelted from a *centumpondium* of the greater weight of ore or metal alloy."

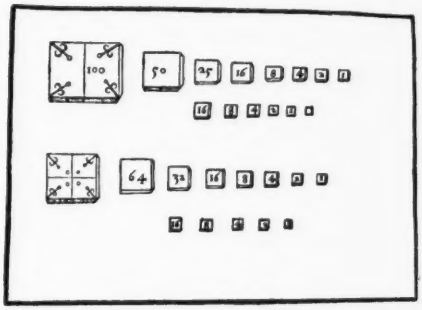


FIGURE 5.—ASSAY WEIGHTS

Two different sets of weights are represented in Figure 5. The upper set which was generally employed has 100 *librae* equivalent to its largest weight, the *centumpondium*, and 16 *uncia* equal to 1 *libra*. The lower set has a different ratio, 112 *librae* being equal to the largest unit.

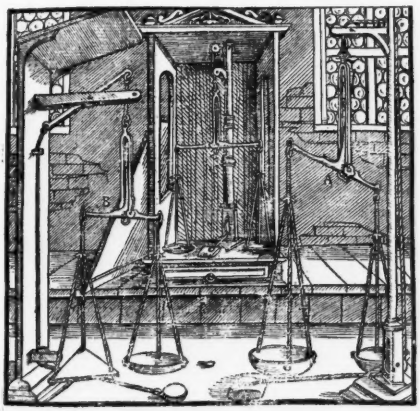


FIGURE 6.—*A*, FIRST SMALL BALANCE; *B*, SECOND; *C*, THIRD, PLACED IN CASE

Figure 6 shows three types of balances. The first balance, used for weighing lead and fluxes, was a typical rough balance. The second was somewhat more delicate and was used to weigh ore or the metal to be assayed. The third balance, which was honored by being enclosed in a case, was used to weigh the beads of gold or silver. The balances of the modern assayer far surpass any of the 16th century, and here is where Agricola's chief trouble might arise.

He concludes by saying—"Perhaps I have used more words than most

highly skilled in the art may require, but it is necessary for the understanding of these matters."

It is interesting to examine Agricola's attitude toward the alchemists. He lived in the later days of alchemy, but he was not carried away with the vain boastings of transmutation. He usually denounced such ideas and dismissed the subject by saying that "the matter is dubious." He suggests that if it were possible to create precious metals from base ones—"they would have by today filled whole towns with gold and silver." However, he could not completely escape the influence of alchemistic writings, which he must have perused, for in several places we find him recommending the use of urine as a quenching medium; and elsewhere mentioning the presence of gnomes or spirits in the mines. But, in general, as the translators have written in the introduction, his statements appear "as crystal to mud in comparison with those of his predecessors—and of most of his successors for over two hundred years."

STUDENT CONTRIBUTIONS

Is your chemistry club carrying on some worthwhile project? Have you, yourself, an interesting chemical hobby? Have you devised an original chemical experiment or piece of apparatus? Have you built a working model of a chemical plant or a piece of chemical machinery? Have you a chemical collection of any kind?

Tell us and other students about it in an article of not more than one thousand words. If possible, illustrate your article with drawings or photographs, or both. In preparing your manuscript, observe the directions to authors set forth on page 188.

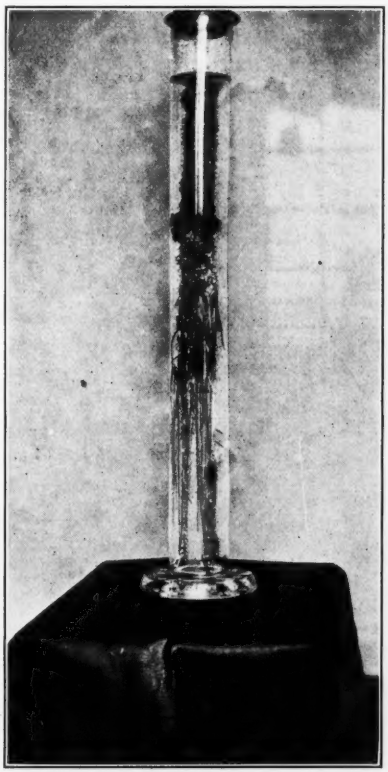
Ten dollars will be awarded the high-school or undergraduate college student contributing the best item received on or before March 15, 1929. Five dollars will be paid for any other articles accepted for publication. Address your contribution to the Associate Editor, JOURNAL OF CHEMICAL EDUCATION, The Johns Hopkins University, Baltimore, Md.

Mercury Compound Kills Grain Diseases. Mercury in an organic compound, ethyl mercury chloride, has been shown to be a good medicine for seeds threatened with fungus infection, the American Phytopathological Society was recently told by Dr. W. H. Tisdale and W. N. Cannon of New York. Treatment with a one and one-half per cent solution of this compound has cleaned seed oats of both loose and covered smut, sorghum of covered smut, and barley of strips and loose smut.—*Science Service*

LEAD TREE. (ARBOR SATURNII)*

CHARLES H. STONE, ENGLISH HIGH SCHOOL, BOSTON, MASSACHUSETTS

It is well known that a metal can be displaced from a solution of its salt by the action of a more active metal. Thus, copper displaces silver, lead displaces copper, and zinc displaces lead from water solution of the acetates or nitrates of silver, copper, and lead. These different displace-



A LEAD TREE AFTER THREE WEEKS' GROWTH

A CLOSER VIEW

ments can be shown nicely by the preparation of "trees." In the case of the displacement of copper by lead, it is advisable not to use a solution of

* The work of preparing and photographing this lead tree was done by Gaffer, Gavin, and Robbins, students at the English High School. After three weeks, the filaments of lead are about twelve inches long.

either the sulfate or chloride of copper since the lead salt formed in each case is insufficiently soluble.

It is possible, by pursuing the following procedure, to prepare a lead tree of much more than the usual attractiveness. Prepare a 3% solution of lead acetate in distilled water to which a few drops of acetic acid are added. Filter the solution into a tall narrow jar; a 250-cc. graduate answers admirably. The liquid should rise to within about an inch of the top of the jar. Select a cork stopper which fits snugly into the top of the jar and bore a small hole in its center. Choose a round battery zinc rod and saw it into two parts of equal length. Pass a non-tapering screw through a metal washer, then through the cork, and screw it firmly into the zinc rod at the end already carrying a threaded hole. Wrap the zinc rod tightly with a layer of asbestos paper and tie the paper firmly in place; the entire length of the zinc should be covered.

Insert the cork into the top of the jar so that the zinc hangs vertically in the center of the liquid, not touching the side of the jar. The liquid should not rise to touch the cork. Set aside for several days. The asbestos paper slows down the displacement so that the "tree" forms very slowly. After several days long feathery streamers of lead will form, growing slowly down and reaching eventually to the bottom of the jar. In the specimen recently prepared by the writer these streamers developed in about a week and are some six or eight inches in length and present a beautiful appearance.

It is, perhaps, unnecessary to say that the jar should not be handled or carried about more than necessary since the lead streamers are easily dislodged.

SCIENCE, ART, AND IDEALS*

Poe long ago complained that science had driven the hamadryad from her grove; in other words, that science tends to destroy our sense of the wonder and mystery of nature. The scientist is presumed to be insensible to beauty. A primrose by the river's brim, organic compounds is to him, and nothing more. Yet science is itself an expression of the artistic impulse. The man who devotes his days to scientific research finds the same sense of artistic satisfaction in the growing harmony and completeness of his work that the painter or sculptor does. And a living tree, in the midst of a sylvan grove, is no less beautiful and is infinitely more wonderful now that we have ceased to personify it.

The spirit of science, furthermore, is in harmony with the finest ideals of character, for the scientific worker needs such qualities as patience, disinterestedness, earnestness, devotion, honesty, diligence, and system. He must be impartial, fairminded, and devoid of prejudice. He must be bold in venturing into new fields, stout-hearted in defending his conclusions, and brave in admitting error. He must be tolerant and teachable.

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* From the *Industrial Bulletin* of Arthur D. Little, Inc., November, 1928.

TEXTILES AND TEST TUBES.* PART II

PAULINE BEERY MACK, PENNSYLVANIA STATE COLLEGE, STATE COLLEGE, PENNSYLVANIA

Creative Chemistry to the Rescue

It was here that the creative chemist stepped into the picture. The longing of the human race for a certain commodity had out-distanced Mother Nature's ability to furnish this commodity. In other words, there were not enough worms in existence, or the possibility that there would ever be enough because of the fact that few places in the world had the proper temperature-humidity conditions for sericulture. This made it impossible to supply all of the silk wanted by people in all walks of life.

MARJORIE LAWS OF OSWEGO, KANSAS, A SOPHOMORE AT THE PENNSYLVANIA STATE COLLEGE WEARING A $25 WEDDING OUTFIT WHICH EXEMPLIFIES THE FOUR TYPES OF RAYON

The time taken by a silkworm to spin a cocoon is three to four days. During one minute it makes about six elliptical movements of the head, spinning during this time four to six inches of fiber. A total of 300,000 movements of the head are made during the entire spinning of the cocoon. The cocoons are made of an unbroken double fiber from 1500 to 4500 feet in length. The chemist has designed equipment which exceeds the speed of the silkworm hundreds of times over.

Using raw materials which, in themselves, would be useless for making textile fabrics, science has created new fibers which have no exact counterpart in nature at all. Even the lowly cornstalk has found an important place in the modern scheme of things by the discovery that the chemist can convert it into cellulose pulp which he hopes to make suitable for the production of rayon and other synthetic cellulose articles.

In the accompanying picture, we have an American girl, dressed in her

* This article is an elaborated revision of a paper read before the Institute of Chemistry at State College, Pennsylvania, July 26, 1927. The original paper was published in the *Chemistry Leaflet*, **1**, No. 14 (Jan. 14, 1928).

wedding costume; she is clad from head to toe (except her shoe soles) in synthetic materials. Her dress is of cellulose acetate fibers (celanese) and viscose rayon combined; her stockings are of Bemberg rayon; her underwear is made of fibers produced by the nitrocellulose process (tubize); and her veil is of tulle—also a nitrocellulose product. Besides the textile fabrics used in the bride's costume, other synthetic materials are in evidence. The beads are of collodion with fish scale essence as the iridescent material placed in thin-walled glass spheres. The orange blossoms are precipitated calcium carbonate coated with paraffin. Her slippers are of rayon and metal threads, the metal a tin-copper alloy. Even the traditional garter, embodying something old, something borrowed, and something blue is made of rubber rendered adaptable by chemical treatment, and is covered with rayon and ornamented with rayon roses. The entire bridal costume was produced at a cost of less than twenty-five dollars.

And as for the remainder of the bride's trousseau, she now has an unlimited number of synthetic textile fabrics from which to choose. Brocaded rayon velvets; rayon fabrics, for sport wear; charming color effects made by combing two kinds of rayon with different dyeing properties; and dresses and shawls embroidered with lustrous rayon threads. Hats of rayon, of rayon plush, or of cellophane. Beads of collodion, of glass, of casein, or of bakelite.

Réaumur

Réaumur, a French physicist living from 1653 until 1757, was the first person who dreamed of the possibility of making silk artificially. He published "A History of Insects" in 1754 in which he makes the following specific prophecy:

> Silk is merely a liquid gum which has been dried. Could we not make silk ourselves with gums and resins? This idea, which at first glance might appear fanciful, is more promising when closely examined. It has already been shown to be possible to make varnishes which possess the essential qualities of silk. . . . But how can we draw these varnishes into threads? We cannot, perhaps, hope to draw out the threads as fine as those obtained from silk worms, but this degree of fineness is unnecessary and it does not seem impossible either to spin hem into threads, or to spin them even as fine a natural silk, when we consider to what an extent art may be carried.

Count Chardonnet

Although numbers of people tried to act upon Réamur's suggestion, none of the varnishes known at that time were found to be adaptable for making textile fibers. In 1875, the German chemist, Schönbein, discovered a method of making nitrocellulose which is now described in all of our elementary textbooks—the treatment of cellulose with a mixture of concentrated nitric and sulfuric acids. Ten years after this discovery, a French chemist—Audemars of Lausanne—actually took out patents for the production of "artificial silk" from a solution of nitrocellulose in various

solvents. The fiber which this scientist made, however, was not practicable from a textile point of view.

It was not until 1884 that a successful artificial textile fiber was produced. The inventor was Count Hilaire de Chardonnet (1840–1924), a French scientist who had studied under Pasteur at the École Polytechnique in Paris. Chardonnet first became interested in silk while he was a student. His interest resulted from the fact that Pasteur was, at that time, engaged in a study of the diseases of the silk worm.

It had long been known that silk was produced from a gum exuded by the worm in the form of a pair of fine filaments. The filaments are covered over with a second type of secretion, which cements the fibers together. The fiber proper consists of a protein to which the name of *fibroin* has been assigned, but whose exact chemical structure is not yet understood. Elementary analyses of this substance have shown that it has approximately the composition given by the empirical formula $C_{15}H_{23}N_5O_6$. The gummy sheath which cements the two fibers together is called *sericin* and is similar in composition. Analysis shows it to have the elementary composition shown by the formula $C_{15}H_{25}N_5O_8$. The sericin is removed from the silk by a boiling-off process, the fiber proper being comparatively insoluble in boiling water and the gum soluble.

Chardonnet's first inspiration was to try to digest the leaves of the mulberry tree—the food on which the cultivated silkworm feeds—by some chemical means, and then force the liquid through some small opening, such as a capillary tube. Reasoning from this point, he came to the conclusion that the leaf of this tree consisted essentially of cellulose, and that it did not differ materially from cellulose from other sources. But it required many years to arrive at this conclusion.

Chardonnet's preliminary work dated from 1878. It included a study of the life and habits of the silkworm, and a study of the chemical nature of the mulberry leaf and body of the tree. It took him some time to free himself from the belief that there was some peculiar characteristic of the food of the worm which made it possible for silk to be produced. In fact, the first successful fibers made by this great research worker were produced by a series of chemical treatments from the cellulose of mulberry trunks and limbs. Later he tried wood from other trees, and finally, found that he could use fine white tissue paper or cotton. In fact, the last-named products served much better for his process than wood pulp.

The Chardonnet process consists briefly in *nitrating* cellulose with nitric and sulfuric acid; *dissolving* the nitrocellulose formed in an ether-alcohol mixture; *spinning* the filaments by forcing the liquid through minute orifices either into the air, or into a hardening bath; denitrating; bleaching; and washing.

The process may be outlined briefly as follows:

COTTON LINTERS[1]
treated with $HNO_3+H_2SO_4$
NITROCELLULOSE
dissolved in ether-alcohol
SOLUTION RESEMBLING COLLODION AND CONTAINING ABOUT 20% NITROCELLULOSE
spinning
NITROCELLULOSE FILAMENTS
denitration with sodium or ammonium hydrosulfide
CELLULOSE FIBER
Bleaching, usually with chlorine
CHARDONNET SILK, or NITROCELLULOSE RAYON

In the nitration reaction, nitro (NO_2) groups are caused to replace some of the hydrogen of the original cellulose molecule. The higher nitrocelluloses constitute some of our best known explosives, and even the lower ones will explode with considerable vim. The nitration is only caused to proceed in the case of making textile fibers until a mixture of the lower nitrates is formed, the mixture probably having somewhat the following constituents:

$$(C_6H_9(NO_2)O_5)_x$$
$$(C_6H_8(NO_2)_2O_5)_x$$
$$(C_6H_7(NO_2)_3O_5)_x$$
$$(C_6H_6(NO_2)_4O_5)_x$$

In Chardonnet's first memoir to the French Academy, he does not mention denitrating the fibers. As a matter of fact, the first fibers which he produced were quite inflammable, and additional work had to be done by the inventor to make the product safe for use. In 1889, five years after the first publication of his results, before he had perfected his fiber commercially, he established the first synthetic fiber plant in his own home town in northern France, Besançon, as soon as he could interest enough people in the proposition to capitalize his venture.

In order to have the outstanding events which contributed to the very complicated history of rayon clearly set before us, we take the liberty of copying the following chronological table from Avram, "The Rayon Industry:"

1754—Réaumur, French scientist, pointed out the possibility of producing artificial fibers along the principle shown by the silkworm and the spiders.

1855—George Audemars, from Lausanne, Switzerland, took out (in England) the

[1] Cotton linters are obtained from the linter-gin, which strips the fibers clinging to the cotton seeds obtained from the first ginning. To this other combings are added. The waste fibers thus obtained must be purified by treatment with NaOH followed by bleaching.

oldest known patent for an artificially produced, silk-like fiber, made of collodion and rubber.

1857—E. J. Hughes, England, patented a glass-like fiber composed of starch, glue, fats, tannin, etc.

1862—Ozanam, in an article published in France, made the first known mention of spinnerets consisting of small holes through which the plastic mass is forced to form a filament.

1883—Swan in Bromley, England, invented a fiber by dissolving nitrocellulose in acetic acid.

1884—Count Hilaire de Chardonnet, of Besançon, France, took out his first patent on the first commercially successful Rayon filament; he also patented machinery in which many principles adhered to at present are incorporated.

1888—Chardonnet patented a process for the partial denitration of his fiber.

1889—Dr. Franz Lehner, at Augsburg, Germany, made a fiber from silk waste. He also patented a method of stretching partly dried filaments in order to obtain finer fibers.

1890—Dr. Franz Lehner, at Zürich, Switzerland, developed the principle of continuous spinning of the fiber.

1890—Louis Henri Despaisses, in France, patented the first process for making rayon from cellulose dissolved in ammoniacal copper oxide.

1892—Charles Frederick Cross, Edward John Bevan, and Clayton Beadle, in London, invented the so-called viscose process.

1893—Denitration process was greatly improved in France.

1894—C. F. Cross, England, patented the first acetate of cellulose process. This was the original form of celanese.

1894—Count Hilaire de Chardonnet patented a spinneret designed especially for his fiber.

1898—William Porter Dreaper and Harry Kneebone Tompkins, in England, took out the first patent for dissolving cellulose in chloride of zinc or some other zinc salts.

1898—Chardonnet placed on the market a vastly improved rayon fiber, denitrated and given greater affinity for dyestuffs and rendered less inflammable.

1899—Dr. Max Fremery and John Urban, in Germany, invented processes for treating cellulose before it is dissolved in ammoniacal copper oxide.

1899—Adam Millar, Glasgow, patented the first so-called artificial tulle lace, using a solution of gelatine, rubber, etc., as a base.

1900—Dr. Emil Bronnert, of Alsace, and Dr. Max Fremery and John Urban, of Aachen, Germany, invented processes for dissolving cellulose.

1900—Charles F. Topham, London, patented a machine for winding cellulose filaments into cakes, by means of the centrifugal spinning box or pot.

1900—The Vereinigte Kunstseidefabriken A. G., Frankfort-am-Main, produced imitation horsehair from cellulose solution.

1900—The Glanzstoff-Fabriken A. G., in Elberfeld, Germany, developed the first commercially successful machine for spinning filaments continuously.

1901—Dr. Edmund Thiele, Barmen, Germany, invented an improved process for drawing filaments into finer fibers.

1904—The first solvent recovery process for nitrocellulose manufacture was patented by J. M. A. Denis, in Rheims, France.

1905—Rudolf Linkemeyer, Brussels, patented a hollow revolving drum inside of which the hardened fiber is coiled instead of being wound on a cylinder.

1906—The Vereinigte Glanzstoff-Fabriken A. G., Elberfeld, Germany, patented

machinery for the continuous spinning, washing, drying, winding, and twisting of the filaments without interruption between these processes.

1907—The Compagnie de la Soie de Beaulieu, in France, patented a process for denitrating yarn before the filaments have become hard.

1907—The J. P. Bemberg A. G., in Barmen-Rittershausen, Germany, patented rayon-making machinery which agitates the coagulating liquids, claiming to avoid breakage.

1907—Prince Guido Henckel von Donnersmark, in Sydowsaue, Germany, uses cellulose acetate as a base for rayon yarn.

1907—Marius Ratignier, in Villeurbanne, France, patented an improved process for so-called artificial tulle or lace.

1908—Bernard Loewe in Paris, invented a new spinning process in which a large space is provided between the spinnerets and bobbins, allowing the filament to dry in the air.

1908—The Vereinigte Kunstseidefabriken A. G., in Kelsterbach a. M., Germany, invented an imitation horsehair, using cuprous chloride.

1908—Samuel Courtauld & Co., Ltd., London, patented a spinning machine with hollow spindles equipped at one end with spinnerets.

1910—The first industrial plant for the manufacture of rayon (according to the viscose process) in the United States was started at Marcus Hook, Pa.

1911—Paul Gerard, France, produced straw-like tubes from cellulose solution.

1912—Rayon was used in quantities for hosiery.

1912—Peter Spence & Sons, Ltd., in Manchester, England, patented a metallic finish produced by precipitating copper on the surface of the fiber.

1913—Samuel Courtauld & Co., Ltd., England, patented a process for oxidizing nitrate of cellulose previous to its conversion into viscose.

1916—The first knitted fabric for outerwear, made exclusively from rayon, appeared on the market.

1919—First experiment on a small scale in this country to use rayon in underwear.

1924—The term "rayon" in place of artificial silk or similar names is generally accepted by the trade in the United States and England.

Chardonnet's original plant in Besançon, France, continued to operate successfully until the opening of the World War in 1914. At this time, the French government took it over for the manufacture of gun cotton. At the close of the war, the plant was sold to the French associates of the du Pont interests. The plant is operating today, using the viscose process (to be discussed later) rather than that of Chardonnet.

One of the early plants to manufacture textile fibers by the nitrocellulose process was located at a place in Belgium which was named Tubize on this account. The Tubize Artificial Silk Company of America, founded in 1920, is an outgrowth of the original concern and it uses the Chardonnet process. The plant of this company is at Hopewell, Virginia.

Cuprammonium Rayon

The second type of synthetic textile fibers to be invented was the cuprammonium filament presented for patents in 1890 by a French scientist named L. Despaisses. Because the inventor died before the final accept-

ance of the patent, however, it was not published according to the French law of that date. In 1897, H. Pauly patented practically the same thing, with but a few modifications, in England. The process consists of digesting cellulose (usually cotton linters) in an ammoniacal solution of copper sulfate, and then forcing this liquid through the tiny orifices of a spinneret into a hardening bath of dilute acid.

In 1899, Fremery and Urban took out patents for improvements on Pauly's process, which led to the establishment of the Vereinigte Glanzstoff-Fabriken at Elberfeld, Germany.

In 1901, Dr. Edmund Thiele, of Barmen, Germany, took out patents for an improved process for drawing filaments into finer fibers by a method of "stretch spinning." His invention consisted in drawing the filaments out to the desired size before coagulation, and keeping them under tension for the short time necessary for them to harden. The firm of J. P. Bemberg A. G., of Barmen, Germany (established in 1792, and operating as a dye works and mercerizing establishment from that time on), began making synthetic fibers on an experimental scale, using the process owned by the Vereinigte Glanzstoff-Fabriken for producing the fibers, and that of Thiele for drawing them into extremely fine filaments during spinning by the "stretch" method. When these combined processes were fully worked out and placed on a paying basis, the J. P. Bemberg Company of Germany began to devote itself exclusively to the manufacture of synthetic textile fibers.

The American Bemberg Corporation, an offshoot of the German concern, was established in 1925. The works are located between Johnson City and Elizabethton, Tennessee.

The Bemberg process is, briefly, as follows:

CELLULOSE
(Usually in the form of cotton linters)
↓ Dissolve in ammoniacal copper oxide
CUPRAMMONIUM SOLUTION OF CELLULOSE
↓ Spinning (under tension)
CELLULOSE FILAMENT (containing impurities)
↓ Bleaching and washing
CUPRAMMONIUM RAYON
(CELLULOSE)

A modification of the cuprammonium process was worked out by Dr. Emile Brennert of Strousburg, Alsace, in which the raw material is dissolved in ammoniacal copper carbonate. This process is being used in this country in a newly established plant at Utica, New York, owned by the Shenandoa Rayon Corporation.

Viscose

Only two years after Despaisses' first announcement of cuprammonium filaments, two English inventors—Cross and Bevan—discovered an entirely new method of digesting cellulose. The product developed by these men was produced in two stages: (1) the digestion of the cellulose by sodium hydroxide, and (2) the conversion of the alkali-cellulose thus formed into a soluble xanthate by treatment with carbon disulfide. A brown, viscous liquid is produced as a result of this treatment, which the inventors named *viscose*. Hence the name of the process.

It was three years after Cross and Bevan had worked out the "viscose" method of dissolving cellulose before a serious study of the spinning capabilities of the liquid was undertaken. This research was done at the Incandescent Lamp Works at Zürich, Switzerland, with the idea of applying viscose filaments to the manufacture of incandescent gas mantles. A measure of success attended this first venture, but it was found impossible to produce continuous threads of the quality and quantity necessary to market the product as a yarn.

The Topham Box

It was not until 1900 that the first exhibition of viscose rayon goods took place. It was almost ten years after this date before the major technical difficulties of the process were solved. The spinning and twisting of the individual threads was the part of the process which gave most difficulty. This part of the problem was solved by an English inventor named Topham, who devised a centrifugal box for drawing the fibers forward out of the coagulating bath, twisting them into a thread, and winding the threads into a veritable cocoon of mammoth proportions.

When the fibers harden in this tightly wound condition, they form what is called the "cake." The yarn can be unwound from this with little difficulty.

After the viscose process was finally perfected through patient and continuous research participated in by a number of agencies it outdistanced all other processes in quantity production. The reasons for this are fourfold: (1) well-organized research; (2) strong financial backing (the inventors secured the backing of Samuel Courtauld & Co., Ltd., silk manufacturers of England); (3) the invention of the Topham box which solved the spinning difficulties and made quantity production possible; (4) the discovery of the fact that either wood pulp or cotton linters would serve as a satisfactory raw material.

The rights and patents of the viscose process were sold to many concerns in various parts of the world. The Viscose Company, established in the United States in 1911, was the first company to manufacture rayon in this

country by any process. The company has plants at Marcus Hook, Pennsylvania (said to be the largest rayon plant in the world), at Lewistown, Pennsylvania, at Roanoke, Virginia, and at Parkersburg, West Virginia. It has a plant at Nitro, West Virginia, which produces cellulose boards from cotton linters, and ships these to some of the other rayon plants as a raw material.

The du Pont Rayon Company is the second largest producer of viscose rayon in this country. It operates under patents secured through a merger with Comptoir des Textiles Artificiels, Paris, which owned the right to use this process. The works of the du Pont Rayon are at Buffalo, New York, and Old Hickory, Tennessee.

There are something over one-half dozen other plants in this country manufacturing rayon by the viscose process.

The viscose method of producing rayon may be summarized briefly as follows:

WOODPULP (usually spruce) OR COTTON

↓ Digested with NaOH

ALKALI CELLULOSE "CRUMBS"
Probable composition shown by the formula
$(C_6H_{10}O_5)_2 \cdot NaOH$

↓ Treated with carbon disulfide

CELLULOSE XANTHATE
Possible formula $(C_{12}H_{19}O_9)—O\diagdown \atop \quad\quad Na—S\diagup C=S$

↓ Dissolved in an alkaline solution

VISCOSE

↓ Spinning into acid bath

FIBERS OF IMPURE CELLULOSE

↓ Washing bleaching

VISCOSE RAYON
(CELLULOSE)

From Dope to Dresses

The fourth type of cellulose textile fibers—those from cellulose acetate—were first worked upon by Cross and Bevan, the inventors of viscose. A refined modification of this pioneer process has been applied since the World War to the manufacture of a product called celanese. This product promises to offer Cross and Bevan's favorite fiber—viscose—some very interesting competition.

Soon after Cross and Bevan's first work with cellulose acetate fibers (in 1892) they dropped the process because of technical difficulties involved. Workers in the United States and Germany spent some time in improving it, but it was never advanced to the commercial stage.

At the close of the World War, the extensive "dope" plant located at Spondon, England, found itself with equipment for making airplane wing dope, but with no demand for the product. The method used by this plant (the British Cellulose and Chemical Manufacturing Company) for making cellulose acetate dope was based on processes worked out under the pressure of war-time needs. The inventor, H. Dreyfuss, a Frenchman, was responsible for this process, which consisted of producing acetone-soluble cellulose acetate.

After surveying the field carefully, the owners of the plant decided that the best outlet for using Dreyfuss cellulose acetate dope was in the making of rayon. After overcoming many technical and financial difficulties, they placed *celanese* on the market.

The Celanese Corporation of America, with a plant at Amcelle, Cumberland, Maryland, is a branch of the English Cellulose and Chemical Manufacturing Company. There are a few other plants in the world manufacturing rayon by the use of various modifications of the cellulose acetate method, but they do not, as yet, produce any significant quantity of yarn.

A condensed diagram of the cellulose acetate process for yarn manufacture is given below:

CELLULOSE (cotton linters, usually)
Treated with ↓ acetic anhydride
CELLULOSE ACETATE
Dissolved ↓ in acetone
CELLULOSE ACETATE SOLUTION
Spin ↓ ning
CELLULOSE ACETATE FIBERS

One of the chief virtues of cellulose acetate rayon is the fact that it resists water. This resistance to water makes it difficult to dye, but this problem has been met by the chemist, and capitalized. Dyes which are applicable to viscose rayon, for example, will not color cellulose acetate, and vice versa. This makes it easy to weave a special pattern with two rayon fibers which, to all outward appearances look alike, and then dye them in one bath with the production of a beautiful two-color effect. None of the four types of rayon, for that matter, has dyeing properties similar to any of the others. Therefore, a remarkable field for combining these fibers into one fabric and cheaply dyeing them in one operation is opened up.

CHEMISTRY IN 1928

Gluconic acid, a chemical hitherto obtainable only at a price of $100 a pound, was produced at 35 cents a pound by chemists at the Color Laboratory of the U. S. Department of Agriculture, using a species of mould growing on a glucose solution.

Edible fats and fatty acids for soap making were made from paraffin through catalytic methods developed by the chemists of the German Dye Trust.

A magnetic theory of catalytic action in which molecules and atoms are conceived as having two poles like a bar magnet was advanced by Dr. Karl Krauch, German chemist.

Wallboard is being manufactured from cornstalks in a special semi-commercial plant set up at Ames, Iowa, by the U. S. Bureau of Standards in coöperation with Iowa State College.

A commercial plant for making paper out of cornstalks was built in Illinois, the first of its kind.

The process for converting wood waste into an edible carbohydrate suitable for hog food devised by Dr. Friedrich Bergius, German chemist, was improved to the point of semi-commercial production.

The U. S. Bureau of Chemistry and Soils has evolved two methods of making from corncobs insulating briquetts to be used as a substitute for cork, especially in small refrigerating units.

A successful substitute fabric has been developed to replace goldbeater's skin in the making of gas cells for airships, and several months' use in the "Los Angeles" shows the new material to be cheaper and fully as good.

Anthraquinone, a basic raw material in the manufacture of dyes, was made by cheaper methods involving the use of catalysts or solution in furfural as a result of research by Dr. A. O. Jaeger of Pittsburgh.

New methods of making artificial rubber were announced in Germany, though the process was not divulged.

A new explosive, known as "radium atomite" and claimed to be superior to T. N. T. or dynamite, was demonstrated to army engineers by Capt. H. R. Zimmer, of Los Angeles.

Synthetic sugar, from fructose and glucose, was made by two Swiss chemists, Prof. Amé Pictet and Hans Vogel.

"Bios," a vitamin that promotes the growth of yeast, was obtained in pure crystalline form by Dr. W. Lash Miller of the University of Toronto.

Experiments by dairy experts of the U. S. Department of Agriculture demonstrated that milk exposed to sunlight develops undesirable flavors and odors, whereas milk kept in the dark does not.

"Sunshine pills," consisting of synthetic vitamin D, made by exposing ergosterol from yeast to ultraviolet rays, were placed on sale in Germany and England as a substitute for cod-liver oil.

An ultraviolet irradiated food was placed on the market, a commercial application of the discovery that ordinary foods exposed to ultraviolet rays promote the formation of healthy bones and teeth in children and young animals.

A new way to preserve ether for as long as eight months without spoiling or deterioration was devised by S. Palkin and H. R. Watkins.

A new system of chemical shorthand was developed by Louis A. Leslie of New York and Dr. C. A. Jacobson, professor of chemistry at West Virginia University.

The 1928 Nobel prize for chemistry was awarded to Dr. Adolf Windaus of Göttingen, Germany, for his part in experiments proving that ultraviolet light, either in sunlight or artificially produced, will activate ergosterol and confer on it antirachitic properties.

The Nobel prize award for chemistry, 1927, went to Prof. Heinrich Wieland, of Munich, Germany, in recognition of experiments on the complex compounds known as the bile acids.

The presence of free oxygen in the atmosphere of Mars is the best evidence for the possible existence of life there, Prof. H. N. Russell of Princeton declared.

Zinc and boron are needed by plants, Miss A. L. Sommer and Prof. C. B. Lipman found at the University of California.

Borax, in a concentration of one and one-half parts to a thousand of water, was discovered by Professor Robert Matheson and E. H. Hinman of Cornell University to be a fatal poison for mosquito larvae or wigglers.

A new vitamin, needed by young trout for normal growth, was discovered in raw liver by a group of biologists at Cornell University, and received the provisional name "Factor H."

The presence of copper in the diet is a preventive of anemia, Dr. E. B. Hart, of the University of Michigan, found.

Injections of glucose were found to be beneficial in acute cases of encephalitis, the European sleeping sickness.

Means were found for administering chaulmoogra oil, the remedy for leprosy, without the pain and nausea which patients have had to endure in the past.

Eleven lepers were released, by the U. S. Public Health Service, apparently cured and no longer a menace to the community, from the National Leper Home at Carville, La.

The hypothetical element "coronium," visible in the sun's corona during eclipses, may be identical with the rare gas argon, experiments by Dr. Ira M. Freeman of the University of Chicago indicated.

The cosmic rays which bombard the earth from outer space are evidence of the continuous creation of common elements out of electrons there, Dr.

R. A. Millikan and Dr. G. Harvey Cameron, of the California Institute of Technology, announced.

Ultraviolet rays in sunlight are responsible for the ionization of the upper layer of the earth's atmosphere which is connected with the Kennelly-Heaviside layer that reflects radio waves downwards, thus making long-distance radio communication possible, announced Dr. E. O. Hulburt, of the U. S. Naval Research Laboratory.

A red neon arc light, claimed to be capable of shining through fog, and intended for airport beacon use, was invented by Dr. Clifton G. Found, of the General Electric Co., in collaboration with J. D. Forney, of the Cooper-Hewitt Electric Co.

That helium gas leaks slowly through glass, even through high-quality pyrex, was demonstrated by experiments conducted by three Harvard scientists.

A new metal so hard that it bores smooth holes in concrete, or cuts screw threads in a glass rod, was produced from a compound of tungsten and carbon and cobalt by Dr. Samuel L. Hoyt, of the research laboratory of the General Electric Co., and given the name carboloy.

A new water purifier, succinchlorimide, that will not deteriorate with age was announced by its discoverer, Major C. B. Wood of the U. S. Army Medical School.—*Science Service*

Elements' Decay Has Opened New Domain of Science. How the actual disintegration of one element to another, the goal sought in vain by the ancient alchemists, has been found to be continually occurring without human aid, and has opened a new domain in science, was explained recently by Prof. A. A. Noyes, director of the Gates Chemical Laboratory of the California Institute of Technology, and retiring president of the American Association for the Advancement of Science.

Thirty years ago, said Dr. Noyes, about a dozen of the 89 chemical elements had been discovered. Today all are known except three. Then atoms were supposed to look like small solid balls and to be indestructible. Today they are known to resemble miniature solar systems. Some, like those of radium, are found to be disintegrating spontaneously into simpler elements, while others can be made to disintegrate by bombarding them with helium nuclei.

Helium itself, now prepared in quantity large enough to fill huge dirigibles, was discovered in 1895. Since that time, it has been found that helium nuclei are probably building stones in the construction of the other atoms.

Dr. Noyes showed by an ingenious method how helium nuclei, themselves first formed of protons, which are hydrogen nuclei, and electrons, unite with one another and with more protons and electrons to produce the nuclei of more complex atoms. The natural breaking up of radium, with emission of helium, into a series of elements which finally form lead, all of which has been discovered within the past 30 years, was cited by Dr. Noyes as further proof of the way atoms are built.—*Science Service*

PHOTOMICROGRAPHIC APPARATUS*

HENRY DALE ADDISON, MASSACHUSETTS INSTITUTE OF TECHNOLOGY, CAMBRIDGE, MASSACHUSETTS

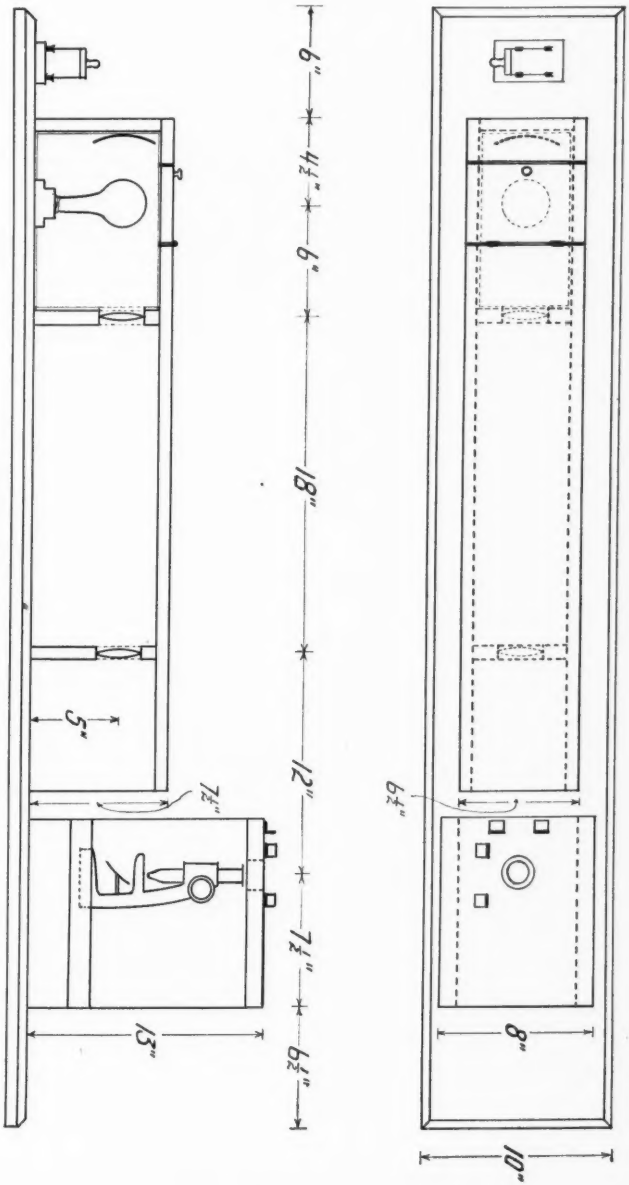
In studying objects through the microscope the author has often wished that he might be able to record what he saw and be able to refer to it at a later date. All attempts to record what was seen by drawing were disappointments. The only method left was photography and from all the available literature little, if any, help was obtained. Practically without exception the apparatus involved was very expensive. In the July, 1927, *Scientific American* was found an article that offered some encouragement. The fundamental ideas of that article have been incorporated, with some modifications, in the apparatus about to be described. At that time the author possessed an inexpensive microscope; "Little Gem" is its trade name. The apparatus was designed primarily for this but may be modified to fit any microscope. In fact, since constructing it, the author has acquired a more expensive instrument and has altered the apparatus to fit it. The apparatus will be described in its original form in the hope that many others who are in the author's position may profit by it. Many an attic laboratory boasts of a "Little Gem" and it is for the benefit of those amateur scientists that this article is forthcoming.

After some experimenting it was found that a 50-watt Mazda light placed three feet from the microscope and focused upon the reflecting mirror by two lenses was sufficient light to give good clear negatives with an exposure of ten seconds. The time of exposure varies, however, with the opacity of the subject to be photographed. It was also found that the farther away the film was the larger the image and consequently the greater the magnification.

In focusing the instrument a ground glass screen placed the same distance from the ocular as the film will be found useful. It was found that when the microscope was in focus to the eye, it was slightly out of focus to the ground glass screen. When once in focus, however, it matters not how far the screen is removed from the ocular as the image will be found to be sharply defined. The only limiting factor is the intensity of the illumination. It is preferable to operate in a dark room, but the author has obtained some splendid photomicrographs in daylight.

At one end of the base is the stand for the microscope. This should be made fairly substantial. Next to this is a cabinet divided into three compartments. The section farthest from the microscope is lined with asbestos paper and provided with a reflector, a socket, and a door or opening of some sort whereby easy access to the interior is possible. A lens of six-inch focal length is placed at one end of this section. Eighteen inches from this is a

* Winner of ten-dollar award in student contest closing January 15, 1929.



PHOTOMICROGRAPHIC APPARATUS

lens of twelve-inch focal length. The cabinet is so placed that the latter lens is just twelve inches from the center of the reflecting mirror of the microscope. At the farther end of the base is a two-pole single-throw switch by which the light may be turned on. The inside of the cabinet is painted a dull black to reduce reflections. The apparatus was put together with screws and is not only very rigid but is also fairly portable. A knife switch was found to be the most satisfactory arrangement for turning on the light because with other types of switches there was more or less jar. On the top of the stand were placed four angle irons in such a position that the camera always occupies the correct position. The microscope sits in a block so fixed that it will always occupy the same position with respect to the light and the camera.

A cheap, yet convenient, holder for the film was found in a Hawkeye camera. The lens was removed and the shutter so arranged that it would stay open for any desired time. With this camera it was necessary to use a roll of film and thus to make six exposures before developing any pictures. This disadvantage may be overcome by the use of a camera that employs a film pack rather than a roll.

WING OF HOUSE FLY

The author used the following procedure in taking photomicrographs. The subject is located and focused with the eye. The ground glass screen is interposed and the image brought sharply into focus. The light is turned off and the camera placed over the ocular. The shutter is then opened and the light turned on for the time required for the exposure.

Photomicrographs made with this apparatus are very clear and show sufficient detail for most purposes. Prints may be made directly from the negatives or if larger prints are desired enlargements may be made without loss of detail. The accompanying illustration is representative of the work of the apparatus.

The author keeps all the prints in a filing cabinet and mounts them on filing cards with the following information: (1) number, (2) subject, (3) exposure in seconds, and (4) on the back of the card, any remarks. Negatives and prints are filed by number: *e. g.*, 3.2 indicates photomicro-

graph number three and cartridge number two. Negatives are filed similarly but in separate envelopes. The subjects are listed alphabetically in a card index so that any print or negative may be readily referred to.

Students who are taking any courses where work with the microscope forms a major part of the work will find that this provides a means of keeping fresh in the mind, and for review purposes, the objects examined. This is not only a very useful instrument but it provides a pleasant spare-time hobby.

Modern civilization rests upon physical science, for it is physical science that makes intelligence and moral energy stronger than brute force. The whole of modern thought is steeped in science. It has made its way into the works of our best poets, and even the mere man of letters, who affects to ignore and despise science, is unconsciously impregnated with her spirit and indebted for his best products to her methods. She is teaching the world that the ultimate court of appeal is observation and experience, not authority. She is creating a firm and living faith in the existence of immutable moral and physical laws, perfect obedience to which is the highest possible aim of an intelligent being.—*Huxley*

We are spinning our own fates, good or evil, never to be undone. Every smallest stroke of virtue or vice leaves its never-so-little scar. The drunken Rip Van Winkle, in Jefferson's play, excuses himself for every fresh dereliction by saying, "I won't count this time!" Well, he may not count it, and a kind Heaven may not count it; but it is being counted none the less. Down among his nerve-cells and fibers the molecules are counting it, registering and storing it up to be used against him when the next temptation comes. Nothing we ever do is, in strict scientific literalness, wiped out.

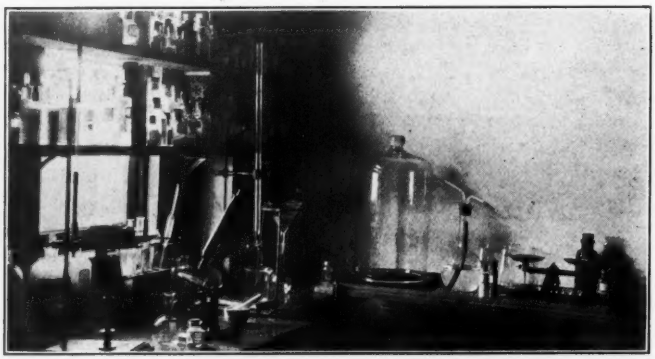
Of course, this has its good side as well as its bad one. As we become permanent drunkards by so many separate drinks, so we become saints in the moral, and authorities and experts in the practical and scientific spheres, by so many separate acts and hours of work. Let no youth have any anxiety about the upshot of his education, whatever the line of it may be. If he keeps faithfully busy each hour of the working day, he may safely leave the final result to itself. He can with perfect certainty count on waking up some fine morning to find himself one of the competent ones of his generation in whatever pursuit he may have singled out. Silently, between all the details of his business, the *power of judging* in all that class of matter will have built itself up within him as a possession that will never pass away. Young people should know this truth in advance. The ignorance of it has probably engendered more discouragement and faint-heartedness in youths embarking on arduous careers than all other causes put together.—*William James*

A RETROSPECT*

EUGENE W. BLANK, PENNSYLVANIA STATE COLLEGE, STATE COLLEGE, PENNSYLVANIA

Yesterday while the wind was screaming by my window and driving against it great sheets of rain I took a sudden fancy to explore the garret of my home.

In a closed but dusty closet I found some of the things most dear to myself. Possibly they may appear trivial to those who have merely to wish for an article in order to get it, but nevertheless they are infinitely important to me. For the things I handled with a feeling akin to reverence were those that had guided me into the realms of chemistry. A miscellany of glass; a variety of sizes, curiously twisted and contorted, lay before me.



VIEW OF LABORATORY IN 1920

A graduate, broken-based but serene in the knowledge of duty rightly done, a dessicator still valiantly defending several crucibles, my precious chemical scale so endeared to me; all these things and many more I brought to light. As I slowly handled my treasures an infinite number of pleasant memories ran swiftly through my mind.

I recalled with considerable pleasure the first order I sent to a chemical firm. With what breathless expectancy I waited for the package! And when it finally arrived how resplendent the cellar looked, how the walls gleamed and shone with highly polished glassware. Their newness had scarcely worn off when a wandering mouse, with an impudent twist of his tail and a shrill squeak, serenely pushed them clear of the shelf.

I also recall with considerable clarity the morning I went to do some work and found my soap-box shelves leaning outward from the wall at a

* Winner of five-dollar award in student contest closing January 15, 1929.

truly dreadful angle. A litter of broken glass and a pool of liquid on the floor made me a pessimist for the rest of the day.

Misfortune never daunts youth; youth that is so secure in the belief that the future will be the summation of all ardent desire. With hard-earned pennies I continued to stock my laboratory, as I fondly called it, with the hope ever before me that some day I might have a place more worthy of the name. Before I became aware of the subtle transformation taking place in me I had become a connoisseur of bottles. My stock became truly varied and extensive. Seeing my determined onslaught on all available space and fearing perhaps that I would soon be in full and in-

ANOTHER VIEW OF LABORATORY IN 1920

alienable control of the cellar, my grandparents readily acquiesced to my proposal to remove to the third floor.

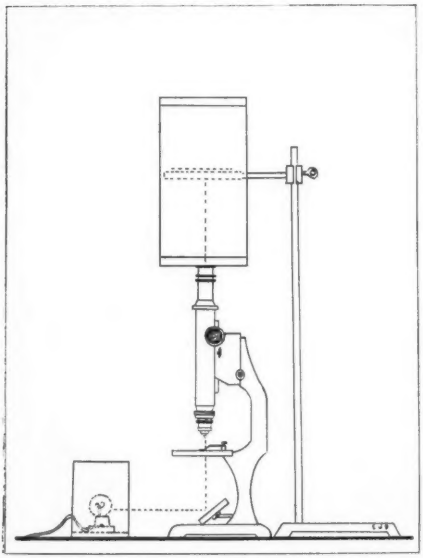
I took complete control of a small room and a hallway and after arranging shelves I had a laboratory truly worthy of the name. By a fortunate turn of circumstance I was able to procure a chemical balance and from that time onward I made considerable progress in mastering some of the intricacies of Quantitative Analysis.

Upon my aunt presenting me with a microscope my attention was drawn to other fields closely allied to chemistry. Soon I was taking microphotographs of the wonders opened to me. I used a home-made apparatus which for inexpensiveness and the ready facility with which it can be constructed I don't believe can be bettered.

Simple Microphotographic Apparatus

To construct the apparatus first procure a round, cardboard box (I used an oatmeal box), and cut a hole in one end just large enough to fit snugly

over the eyepiece of your microscope. Cut a long, narrow slit in the side of the box so that a ring-stand ring can be inserted. Next mount a frosted light bulb in a small wooden box that has a two-inch hole in one side. The latter opening is to direct all the light on the mirror of your instrument. Arrange the apparatus as in the diagram and darken the room. By placing a ground glass on the ring of the ring-stand one can focus the microscope until the image is clear and distinct. Raising the ring with the ground glass will have the effect of increasing the diameter of the image and lowering it will have the opposite effect.



ARRANGEMENT OF APPARATUS FOR TAKING MICROPHOTOGRAPHS

To take a photograph have the image focused on the ground glass, turn off the microscope lamp, and insert a photographic plate in place of the ground glass. By switching on the light for a time the plate will be exposed and will then be ready for development.

If the image on the ground glass appears very dark a longer exposure must be made than is necessary when the image is light and clear. A little practice will soon give one an idea as to how long to expose the plate. The microscope shown in the photograph on page 374 is the one I employed in taking microphotographs.

At present I am unable to do much active experimenting but my introduction to science has been complete and the wish to continue in it is now inherent within me. Nor am I content merely to trifle with the subject. For chemistry has suddenly come to mean a great deal to me, so much, in fact, that I hope to devote all my energies to exploring some portion of its realm and, incidentally, having a great deal of fun in doing it.

There is quite as much education and true learning in the analysis of an ear of corn as in the analysis of a complex sentence; ability to analyze clover and alfalfa roots savors of quite as much culture as does the study of the Latin and Greek roots.—*A. H. Benson*

Correspondence

AN APPARATUS FOR THE PREPARATION OF CHLORINE

In the article, "An Apparatus for the Preparation of Chlorine," Charles H. Stone, THIS JOURNAL **5,** 1292–3 (Oct., 1928), a very fine set-up is shown for the preparation of chlorine for class demonstration. However, it contains one element of considerable risk. The dryer referred to in the text is shown as sulfuric acid in the figure.

When concentrated sulfuric acid is brought into contact with potassium permanganate, a violent explosion takes place. If the generation of chlorine in an apparatus like the above-mentioned is stopped for some purpose, the acid may draw back into the generating flask with unfortunate results. Very serious accidents of this type have taken place and so it would seem desirable to insert a trap between the generator and the dryer when sulfuric acid is used.

This same precaution has been overlooked and explosions have occurred also when permanganate and sulfuric acid have been used in adjacent bottles in a gas purification train.

IRA D. GARARD

NEW JERSEY COLLEGE FOR WOMEN,
RUTGERS UNIVERSITY,
NEW BRUNSWICK, N. J.

Henry Paul Talbot Laboratory, M. I. T. The Henry Paul Talbot laboratory for research in inorganic chemistry at the Massachusetts Institute of Technology was opened early in the fall of 1928. This laboratory is adequately equipped for research in Dr. Talbot's chosen field and accommodates about a dozen students. At the present time the research men are mainly seniors who selected a thesis in inorganic chemistry. On October 26, 1928, a portrait of Dr. Talbot was unveiled in the presence of President Stratton, Professor Keyes, and other members of the staff. On this occasion Professor H. Monmouth Smith gave an account of the work of Dr. Talbot and his service to the Institute. The portrait was the gift of Mrs. Talbot, who had previously given Dr. Talbot's chemical books to the department of chemistry of the Institute. These books are in the library of this research laboratory. The laboratory, the books, and the portrait together constitute a fitting memorial to Dr. Talbot in the institution where he did his life's work.—*Nucleus,* **6,** 91 (Jan., 1929).

New Red Dye Found in Cactus. A new natural plant dye has been discovered in species of cactus by Prof. H. Molisch, well-known German chemist. This brick-red-carmine color has been named "cacto-rubin" and is produced when the cells of the cactus plant die. It is invisible in living cactus plants.—*Science Service*

Chemical Digest

TEACHING SCIENCE AS A "WAY OF LIFE"

"Science is the field in which the human spirit can be expressed at its highest," says Dr. Gerald L. Wendt of Pennsylvania State College. And regarding the training of students of science, Dr. George D. Rosengarten says: "Give (him) the tissue-building material, the fundamentals of science, impart to him its *spirit;* then when he goes out to accomplish his life work he will shape and mold the materials according to the need of time and place and will breathe life into them." But are our present-day educators aware of the many modifications which should be made in our curricula in order to train our students in line with Dr. Rosengarten's suggestions?

We would call your attention to a recent report[1] of John L. Tildsley, District Superintendent of the High Schools of New York City, to indicate the active part our high-school science teachers are taking in pointing out the relative position science should hold among the high-school subjects included in a typical curriculum. This searching and thorough analysis of the teaching of science in high schools of New York City is based upon questionnaires answered by 38 principals, 476 science teachers, and 16,000 pupils. The views expressed by the science teachers seem particularly valuable since the questionnaires were unsigned.

The most valuable information obtained from the teachers was in the replies to the following:

State concisely fundamental objective you vividly have in mind as you begin a period in the science you teach, arranging them in order of importance as determined by the stress you consciously lay upon them.

Some of the objectives stated were:

1. To develop in pupils an appreciation for the scientific method of thinking and the habit of applying this method to other than strictly scientific subject matter.
2. The creation of an abiding interest in the subject itself.
3. Making the pupils walk larger in a larger world.

In addition to those objectives which aim to develop in the student a deeper appreciation of life, many concrete, every-day objectives "which

[1] Teaching Science as a "Way of Life," Ann. Report for 1927–28, *Bull. of High Points,* Oct., **1928.** Copies of this report may be obtained free from the High-School Dept., Board of Education, 500 Park Avenue, New York City.

science teaching should contribute to the making of the effective man" are given. Only a few of these can be listed here.

To develop power of accurate observation; purposeful observation of matters significant to human beings; habits of work and study, skills; to develop the pupil's power of independent learning without being told; to develop scientific skepticism; to cause the pupil to see himself and things about him in right proportion; the building up of intellectual honesty; to develop an attitude of open-mindedness and tolerance.

Commenting upon the adoption of all or any of these objectives, Mr. Tildsley says:

Until the teacher has realized these objectives in himself, or at least honestly sought to do so, it is hopeless for him to set them before his pupils. He is wasting his energy. *A teacher cannot teach that which he himself is not.*

On the realization of these objectives, one of the teachers writes:

The scientific method is a tool, perhaps an essential tool, for effective and rich living. But putting a tool into the hands of a craftsman does not necessitate the fashioning of an object with that tool; unless he realizes the need for an object or is inspired to the creation of one, his tool will lie idle. Even when the scientific method is rigorously and successfully applied by a person in his profession, we know there is often no evidence of this training in situations not directly concerned with his specialty. Unless we ourselves, as teachers, synthesize science with culture, unless our science fits into a philosophy of life, unless in all our dealings and relations we show ourselves possessed of a scientific spirit, unless we are consciously training the emotional life, and, lastly, unless we frequently make the pupils aware of whither we are going and what we are trying to accomplish, we shall not in any way have altered their reaction pattern.

Statements included from the principals of representative high schools of New York City indicate that a large amount of science study is favored.

Considerable space (pp. 82–100) is devoted to presenting the relative merits of the individual laboratory and the demonstration-discussion methods of teaching science. Mr. Tildsley comments upon the evidence presented as follows:

With such positive opinions on the necessity for individual laboratory work as a method of realizing the objectives which a majority of our teachers have accepted, and with so many equally experienced and forward-looking teachers advocating the demonstration-discussion method as a possible and practicable means of inculcating the scientific attitude, it is evident that no decision can be finally made.

Two workable plans are then suggested.

Under Plan I, each teacher would carry four classes, twenty-four periods per week of science teaching, be assigned no duties whatever outside of the science department, but be assigned six periods either to assist in the laboratory, in the preparation room, or in the science office. All physical science classes are to be divided into sections so that one man shall not be responsible for the laboratory instruction of more than at most eighteen pupils.

Under Plan II, each teacher would be assigned five classes, with no assignments of any kind outside the department but would be assigned five periods per week to the preparation of demonstrations under the leadership of the head of the department, who in the future should always be an originating expert demonstrator. If Plan II be adopted, there must be a great improvement in the quality of demonstrations. Some teachers have recommended that one teacher in a department be assigned one class less and be required to prepare the sets for the department. Other teachers have recommended that sets be prepared in a central bureau and drawn by schools like sets of lantern slides.

In an attempt to obtain some constructive recommendations from the science teachers for universalizing the scientific method the following quotation and request were included in the questionnaires.

> The scientific method is everywhere extolled and within certain limits is rigorously applied. Yet the public mind, reinforced each year by a veritable army of youth which is marched through scientific laboratories and lecture rooms, museums and observatories, is as untouched by scientific methods as if no such thing existed. (From Pres. Butler's report for 1927.)
>
> Accepting this statement as valid, what changes in the teaching of science for this army of youth in high schools would you suggest in order to have the scientific method influence more largely their manifold activities throughout their lives?

From the answers to this request "may well come a recasting of our science curriculum, our science content, our science objectives, our science methodology." We quote from the report:

> Many saw very clearly that to cause the *scientific method* so to become a part of the bone and sinew of the boys and girls who throng our high-schools as to influence their manifold activities throughout their lives was to create within a few school generations a new moral and intellectual world.
>
> Some 105 teachers showed by their answers that to cause pupils to understand the nature of the *scientific method* and to apply it within the field of science did not necessarily insure customary actions in accordance with this method in other fields of human activity. They grasped fully Butler's contention and its implications.
>
> Sixty-six teachers saw clearly that the scientific method would not in all probability become the dominating force in conduct with high-school pupils as a mere by-product of the teaching process, but that the building up of the scientific method must become the chief objective of science teaching. To this end they recommended, therefore, definite lessons on the nature and significance of the scientific method and that "throughout the science course the development of the scientific method of attacking a problem must be made the main objective of the class work." As seven stated it, "the scientific method must be built into the lives of our pupils."
>
> With this as the chief objective there was a widespread belief that there must be greater emphasis on individual training; 175 insisted that science classes must be smaller to that end; according to 64 teachers, that there might be more individual laboratory work better done, that sufficient time be given to laboratory work to create a habit, and that the laboratory be a place of scientific investigations of the kind suitable for high-school pupils; 79, that there might be individual problem assignments; 30 urged that the emphasis in science teaching be on method rather than on facts; 8, that a class be resolved into a body of scientists to tackle problems.

A suggestion worthy of serious consideration was "unite all sciences into one department so that training in scientific method may be continuous for four years." Another, "the scientific method should be taught not merely in science but in all subjects." "All other departments must coöperate in suggesting applications of the scientific method." "Apply principles of the scientific method to problems of the pupil's daily life and behavior." The principal and the teachers must be scientific in their attitudes toward all persons and all school matters." "Discuss in the classroom the failure of pupils to apply the scientific method in daily life." "Show pupils they often use scientific method and are not aware of it." "Present every subject in the curriculum so that it can contribute to a general scientific attitude." "Influence Regents to set examinations requiring the use of the scientific method."

"Pupils must be checked up on poor thinking as on poor English." "Point out effectiveness of scientific method as general practice in outside operations." "Scientific training to have any practical influence on students' lives must be directly applied to matters outside the laboratory." "To have scientific method become part of a pupil's mental equipment, he must be reached personally and stimulated to individual initiative, so classes must be small." "Give pupils practice in thinking, reasoning, and talking about things they really know, not guess."

"Suspend judgment yourself till you have the facts." "Make pupils realize that science is a constant factor in their lives." "Impress pupils with necessity of carrying into all walks of life this scientific attitude of mind."

These suggestions, if followed in any one school in their totality, would undoubtedly create an atmosphere and environment favorable to building the *science method* into the lives of boys and girls. To the degree that they form a part of the public mind, it could not be said that "the public mind is as untouched by scientific methods as if no such thing existed."

As a further means of giving an understanding of just what is meant by the scientific method, more than twenty teachers have urged the addition of an "Introductory Course in the Lives of Great Scientists," "a course which gives considerable time to the life work of great men of science and its effects on the course of modern progress." Another teacher puts it this way: "Study experiments conducted by two or three great scientists before they were convinced that they had reached valid conclusions; the emphasis should be on the attitude of the worker, on the spirit in which he worked, rather than on the progress of the research itself."

Some fertile suggestions for the production of truly creative teachings are:

"Synthesize science with culture." "Fit science into a philosophy of life." "Train the emotional life." "More thinking, less memorizing." "Show the growth of the scientific mind of the race." "Stimulate curiosity and inspire a love of science." "Work for open-mindedness." "Substitute quality for quantity of ground covered." "Form habit of intellectual honesty."

The section of the report (pp. 112–28) devoted to personal opinions of students regarding ideal science teachers contains much "food for thought" for those belonging to this professional group. Special qualities mentioned repeatedly were:

The teacher shows a comprehensive knowledge of the subject, has the ability to make work interesting, communicating to the pupils his own enthusiasm; encourages questioning; is patient; drills, summarizes each topic; does not leave a topic before the students are familiar with it; is interested in the individual student; is friendly and sympathizes with the student's difficulties; makes the work practical, bringing in

actual illustrations from life; is impartial; shows a sense of humor; carries on experiments well.

The report closes with (1) numerous suggestions offered by the teachers for improving the teaching of science, and (2) impressions gained from reading the teachers' answers.

Mr. Tildsley lists 26 recommendations which he believes will make more distinctive that which our teachers of science have to offer. Those which are of interest to chemistry teachers are:

1. Since time is needed by science teachers for the preparation of demonstration and laboratory exercises, no non-teaching assignments should be given such teachers other than supervised study assignments in science.
2. Time allowance for physics and chemistry is suggested, as five periods per week for the first semester and six periods, including a double laboratory period, for the second semester.
3. Special effort by the way of meetings of chairmen of the science departments and of teachers themselves is advised, to emphasize the oneness of their work and its aims.
4. The importance of the development of scientific attitudes in pupils warrants a study of ways and means of developing it not only by science teachers but by teachers in the other departments as well.
5. The importance of demonstrations in science teaching warrants the inclusion of a demonstration test as a part of a science teacher's examination for license.
6. The question, "Do the units of science offered for graduation by the New York City high-school pupils in the class of 1928 equip them for living efficiently and happily in this present age?" is asked of all high-school principals.
7. Every teacher of science should join, regularly attend and play his part in the proceedings of the scientific societies, and should read the science periodicals and books which deal with his subject.

Doubtless there are other groups of educators throughout the United States carrying out and profiting by similar investigations. May the cause of science teaching advance thereby! M. W. G.

SCIENTIFIC RESEARCH

Much has been written concerning scientific research, its place in everyday life and education, its possibilities as a career, its contributions to the advances of our modern civilization. This is not surprising, however, when we realize the vastness and the variety of the field which the phrase "scientific research" covers. And then, too, we find:[1]

It is customary to distinguish between research in what is called pure science and research in applied science—the first being that research which is undertaken for the purpose of extending our scientific knowledge without any thought of its industrial

[1] J. W. Williamson, "Careers and Qualifications. XI. Scientific Research," *J. Educ. & Sch. World*, **60**, 789–90 (Nov. 1, 1928).

application or other utilitarian aim; the second being research prosecuted toward some definite industrial end such as the discovery of new materials, the improvement of existing materials, or the invention of new and improved technic in manufacture. The difference is essentially one of intention and the one type of research often merges into the other. A research in pure science may easily be developed along industrial lines and, similarly, applied research initiated for definite industrial purposes ends in nothing but an addition to pure scientific knowledge of no obvious application to industry.

But what are the aspects of science which attract the would-be scientific worker? According to Dr. Wendt[2] there are four.

1. The first aspect, of course, is that of utility, that opportunity which science affords for the earning of a good living. This is probably the first attraction to many, but of least importance.
2. The second is the cultural aspect of scientific study and research, that feature of science which involves avoidance of selfishness, and an interest in science which must be shared with others.
3. The third attractive aspect of science is one which is realized by a successful few. It is the development of a sincere devotion to the subjects in hand. This is a great privilege and the mark of a good scientist. This fervid devotion which causes a man to remain at work in his laboratory in preference to going pleasure-seeking is as unanswerable as the proverbial inquiry, "What does she see in him?"
4. The fourth and greatest attraction of science is that of creative work, the expression of the scientist's devotion to his studies. As art lifts the veil from the reality of material existence, so science lifts the veil from the obscurities of human ignorance and superstition. Science is not just facts, not just laboratory work, not just an interpretation of a mechanistic world. The more the scientist explores the unknown, the more the unknown faces him. The unknown is the inspiration of the scientist.

Having chosen his career, will scientific knowledge, manipulative skill, and ingenuity in devising experiments be sufficient qualities to assure the scientific research worker success? According to Mr. Williamson,[1] No!

The problems to be faced must be viewed from a wide angle and to a far horizon. There are some people who have a natural flair for research and more than a touch of genius in carrying out their work. But we cannot all be geniuses, and much valuable work, perhaps the greater part of the valuable work, is done by those who combine hard thinking with some imagination and patient perseverance. Personality and character are just as essential for success in this career of scientific research as they are in any other career. As Sir John Farmer says: "It may be taken as a certainty that unless a candidate for a post does exhibit that complex group of qualities combined in the word 'able' no selection board will have any use for him."

And Dr. Wendt[2] comments as follows:

To succeed in science one must have not only tools (information) and technic (ability to use information), but also a creative imagination. The famous example of Kekulé's conception of the benzene ring structure supports this statement. The successful scientist must rely to a certain extent upon the subconscious mind, since it has

[2] Report of recent address by Dr. Wendt on "The Place of Research in Everyday Life and Education," *Accelerator*, **13**, 2 (Nov., 1928).

the prime qualities of scientific character. It is observant, but not conscientious. Therefore, the scientist must be somewhat of a dreamer; however, one who can derive practical value from his dreams. He must work not alone with his knowledge, but with his spirit in order to attain the fullest success in his chosen field.

We are all aware of the great development of industrial research during the past two decades. At the recent meeting of the American Association for the Advancement of Science a symposium on Research in Industry was held. As evidence that the industries are actively interested in methods of encouraging competent men to continue in research, we quote from the *Science Service* report of Dr. Willis R. Whitney's address:

The obvious way to encourage is by encouragement, but encouragement has never been standardized. Coin is a token and performs useful functions, and salaries of research men will continue to rise. The accumulated research of an inventor's lifetime used to be sold for what it would bring under a forced sale. Novel processes and new ideas were produced by millions (there are nearly two million American patents), but not one per cent of the hard working inventors was ever rewarded at all. They worked under heart-breaking disadvantages and carried the entire risk of their ventures. The public would have been well justified in sharing the risk with competent workers. Later, it seemed more promising to grubstake the inventor, and this was quite generally done. Many lines of industry were built about a single experimenter.

The more recent scheme is to stake groups of trained and selected investigators and combine their work so that new results may be continuous. This is now a tested development. It is easy to see its advantages. On the whole, it costs the public less and produces better results than the shiftless way of rewarding an occasional inventor who ripened his product on the day the market was exactly ready while declining even to feed the poor fellow who was farseeing and got ahead of the procession.

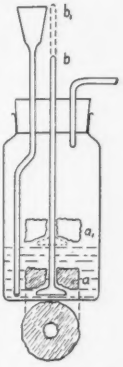
But the unlimited use of coin alone does not guarantee satisfaction anywhere, and we are thus led from the subject of salary, in which no one is expert, to the conclusion that the adequate compensation for encouragement to continue research must include those tokens of appreciation which other creative people generally desire. The public they serve should know of the service. This is a strong survival principle for a race. Publication in some form to bring recognition by one's peers is the nearest equivalent to the artistic painting, the beautiful poem, the enduring sculpture and the splendid architecture of other creators. M. W. G.

German-Austrian Chemical Understanding. Negotiations were carried out between German and Austrian chemical interests in 1927 and the early part of this year with a view to the equalization of prices and a division of markets. The leading negotiators were the I. G. for Germany and the Skoda-Wetzler company for Austria. The Austrian sphere of interest was arranged as follows: Austria, Hungary, South Slav countries, Roumania, Bulgaria, and Turkey, while Germany retained the complete interest in Czechoslovakia, Poland, and Western Europe. This agreement involves among other things, alum, ammonia, "antichlor," chrome alum, sulfur chloride, Glauber's salt, potassium nitrate, sodium, sulfuric acid, hyposulfites, and sodium sulfide. Synthetic fertilizers and certain mineral salts are expressly excluded. A recent article in the *Chemiker Zeitung* suggests that companies outside the agreement (not German and Austrian ones alone) should have a better chance of trading in the South Slav countries as a result of the agreement, in view of the fact that the competition of the I. G. has ceased.—*Chem. Age*, 19, 272 (Sept. 22, 1928).

ABSTRACTS

TEACHING METHODS, AIDS, APPARATUS, AND SUGGESTIONS

Gas Generator. E. J. KRAUS. *Chem.-Ztg.*, **52**, 711 (Sept. 8, 1928).—The accompanying sketch exhibits a tested gas generator, which can be so regulated, without the use of valves, that neither the material (FeS, Zn, etc.) nor the acid must be removed from the flask in order to stop the flow of gas. Through the 3 holes of the rubber stopper are fitted, respectively, a funnel, a glass rod flattened on one end, and a delivery tube. The perforated material (FeS, Zn) of circular form rests on the flattened end of the glass rod. To interrupt the generation of gas, the glass rod is lifted above the surface of the acid (a_1, b_1).



M. W. G.

An Automatic Pipet. MAURICE HYMAN. *Chem. & Ind.*, **47**, 368T (Dec. 14, 1928).—In manipulating an ordinary pipet, difficulty is sometimes experienced in adjusting the level of the liquid, without undue loss of time, accurately to the graduation mark; there is also some risk of drawing the liquid into the mouth. The pipet here described is free from these disadvantages, and is so designed that a large number of equal portions of a liquid can be quickly and accurately measured.

"The stem of the pipet is cut off at the graduation mark and is fitted, by means of a rubber stopper, into the wide tube, *D*, about 3 inches long. This tube is constricted as shown at *A*, and is connected by means of a piece of rubber tubing ($1\frac{1}{2}$ inches long) with a piece of glass tubing, *C*, that serves as a mouthpiece.

"The pipet is filled by suction until the liquid overflows into *D*. The rubber tubing is then compressed, when it will be observed that the level of the liquid falls somewhat below the graduation mark. The mouthpiece is then closed with the forefinger in the usual manner and on now releasing the rubber tubing the liquid rises again in the pipet and overflows once more. The pipet, held by the mouthpiece only, is now raised out of the liquid and the contents are delivered into the receiving vessel, any necessary drainage time being allowed as usual.

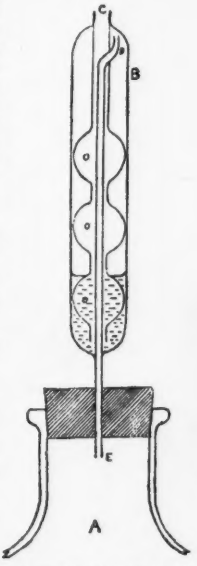
"When the trap *D* becomes full of overflowing liquid, the rubber tubing and mouthpiece are removed and the liquid is poured out; in this way the mouthpiece and rubber tubing always remain dry. The pipet is easily dismantled for thorough cleansing."

E. R. W.

A New Attachment for Bottles Used for the Storage of Standard Solutions. A. G. LIPSCOMB. *Analyst*, **53**, 645 (Dec., 1928).—"The device shown in the diagram has been found satisfactory for the protection of standard solutions against (*a*) contamination by carbon dioxide, and (*b*) concentration caused by replacement of the solution withdrawn, by air having a vapor pressure less than that of the air in the containing vessel. It also provides for the escape of air from the containing vessel when the temperature rises.

"It consists of an outer glass jacket *B*, through the top of which is sealed a tube *C*, which is expanded into three bulbs (000), and opens into the lower part of *B*. A narrower tube *DE* is sealed through the lower end of *B*, and passes axially along *C* almost to the top of *B*, where it is sealed through the wall of *C*, and is bent upward at *D*, terminating near the top of *B*.

"When in use, a suitable liquid is poured in through *C* until it almost covers the lower bulb. The device is then attached to the bottle *A* containing the solution, as shown.



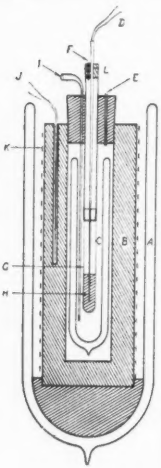
Length of *C* to *E*, 25 cm.; length of *B*, 15 cm.; internal diameter of *B*, 3 cm.; external diameter of bulbs, 2.7 cm.

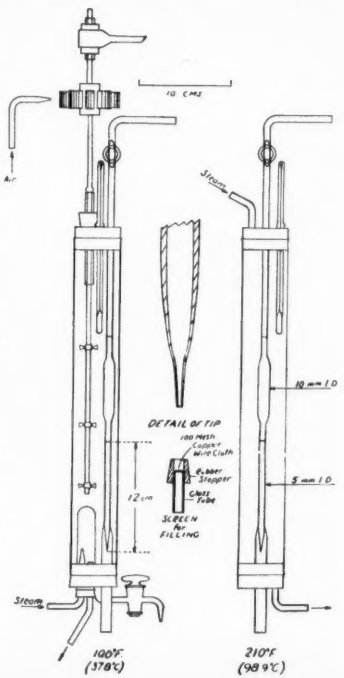
"In the case of caustic soda solutions, the same solution is used in *B* as is contained in *A*.

"On withdrawing solution from *A*, the incoming air is scrubbed free from carbon dioxide, and takes up water vapor to the correct extent. The device can be used for all kinds of solutions by the choice of a suitable liquid for scrubbing purposes. To empty, the apparatus is reversed and suction applied at *E*.

"The dimensions shown are suitable for a ten-liter aspirator bottle." M. W. G.

Freezing-Point Apparatus. E. L. SKAU AND BLAIR SAXTON. *J. Am. Chem. Soc.*, **50**, 2696–7 (Oct., 1928).—The apparatus described is a modification of that reported by Andrews, Kohman, and Johnston, *J. Phys. Chem.*, **29**, 914 (1925). "A cylindrical copper tube or shield (14 cm. long, 5 cm. outside diameter, 2.5 cm. inside diameter) closed on one end is set on a cushion of asbestos in the silvered pint Dewar flask *A*. *K* is a heating coil consisting of a 25-ohm nichrome resistance wound tightly around the metal cylinder and insulated from it by means of a thin layer of mica. A thin-walled freezing-point tube *G* (65 mm. long, 8 mm. diameter) containing the sample, *H*, fits quite snugly over the end of a thin glass tube. The latter extends up through the cork stopper from which the small unsilvered Dewar tube *C* (later work showed this tube to be superfluous) is suspended by means of a wire not shown in the diagram. *I* is an inlet for a stream of hot air (produced by passing air through a small iron pipe loosely filled with copper turnings and wound with a heating element. The sample may also be melted by using a small resistance heater fitting loosely around tube *G*) used in melting the sample *in situ*, and *E* an outlet. The temperature of the shield *B* is measured by means of the copper-constantan thermoelement *J* set in hard solder in a hole drilled for the purpose. A plug of cotton wool prevents too rapid radiation from the top of the shield. The thermoelement *D*, in the melt, is constructed of No. 46 (B. and S. gage) copper and No. 40 constantan wire, the copper being wound around the insulated constantan for a distance of about 4 cm. above the junction in order to minimize the heat conductivity. It is of course an advantage to have the thermoelement directly in the melt but in some cases this is impossible due to the solvent action of the liquid. However, the element responds to a change in temperature with no appreciable lag when protected by a thin-walled capillary tube containing vaseline or some high-boiling liquid (for example, benzophenone). The glass around the thermoelement is much more easily cleaned than the bare thermoelement." M. W. G.





Three Laboratory Devices: A Vacuum Stirrer, a Pressure Alternator, and a Gage for Measured Low Pressures of Permanent Gases in Condensable Vapors. ROGER K. TAYLOR. *J. Am. Chem. Soc.*, **50**, 2937–40 (Nov., 1928).—These three pieces of apparatus are fully described, together with the methods of operation. Excellent cuts of the apparatus are shown. A. P. B.

Apparatus for Micro Gas Analysis. C. H. PRESCOTT, JR. *J. Am. Chem. Soc.*, **50**, 3237–40 (Nov., 1928).—An apparatus is described for the analysis of samples of gas whose volumes would be less than one-third

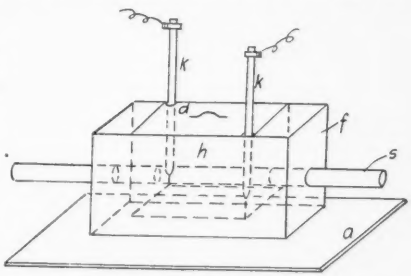
of a cubic centimeter at one atmosphere, determining carbon dioxide, carbon monoxide, hydrogen, and nitrogen. A cut of the apparatus is shown and typical analytical results given. A. P. B.

Apparatus for the Determination of Gas Densities. M. NIKIEL. *Metan*, **9**, 203–10 (1925); *C. A.*, **22**, 4013 (Nov. 10, 1928).—"The density of a gas is compared with that of air by a determination of the time taken for a liquid to flow out of a vessel attached to a gas supply, and then opened to the air. The apparatus is described and figured." M. W. G.

A Precision Pipet Viscometer. S. W. FERRIS. *Ind. Eng. Chem.*, **20**, 974–7 (Sept., 1928).—The viscometer shown in the illustration is constructed entirely of glass. The jacket is filled with water when viscosities are to be determined at 100°F., while steam at normal pressure is passed through the jacket when it is desired to make the determination at 210° F. The pipet has a capacity of about 5 cc., and the orifice is about 0.5 mm. in diameter.

The apparatus is inexpensive, simple to construct, easy to operate, and no measureable change in the constants of the instrument has been found over a period of nearly two years. M. W. G.

A Home-Made Electric Laboratory Furnace. ST. REINER. *Chem.-Ztg.*, **52**, 579 (July 22, 1928).—The oven is built out of firebrick (*f*) and is 60 × 20 × 30 cm. The bricks are cut out with a hammer to fit the fireclay tube (*s*), and the spaces are filled with a firebrick cement. The tube in the heating room (*h*) is covered completely with cryptol. A sheet metal lid (*d*), which tightly covers the heating room, contains two openings through which two carbon electrodes (*K*) pass, reaching down into the cryptol material. An asbestos mat (*a*) protects the table. A resistance of running water is used. A maximum of about 100 amps. is consumed by the furnace. An upper temperature limit of about 2000°C. has been obtained. The electrodes and cryptol must be renewed occasionally, although the author claims he has operated the oven for a month's time without making any repairs. The furnace is cheap and reliable. M. W. G.



The Care of Electrical Instruments. E. S. LINCOLN. *Instruments*, **1**, 475–8 (Nov., 1928).—Listed below are a few suggestions which are well worthwhile to consider by those who have anything to do with electrical instruments of any nature.

(1) "When an instrument is first received a record should be made showing its number, model, and other details. In case of loss at some later date, you can then notify the makers and they will automatically notify you in case it should ever be returned for repairs. Instruments should be listed on the inventory of the company and a careful record made for future use.

(2) "When testing equipment consists of many instruments it is a good policy to distinguish each by a special number instead of using the manufacturer's number upon the instrument. This suggestion may be adopted by a small key tag fastened to the instrument or by means of a small nameplate fastened to each instrument case. Some owners paint the details of the instrument on the outside case. These numbers can be used for reference and quick identification.

(3) "When instruments are kept in cabinets the pigeonhole containing these instruments should be marked with the same number as the instrument, making it easy to locate quickly any particular instrument.

(4) "Numbers and tags should be covered with a transparent varnish or white shellac for protection.

(5) "A form of card is recommended for use in indexing instruments.

(6) "When instruments are not in use they should be put away in some location that is free from dust, oil, heat, moisture, and excessive vibrations. A bookcase or some covered partitions offer good storage space for instruments of any nature. When not in use all instrument cases should be closed, and instruments provided with separate cases should be kept in their containers.

(7) "In making tests it is absolutely necessary that a proper place be selected for

the different instruments, and they should not be placed upon the floor as they are liable to become injured and in that position they are extremely hard to read. When using instruments intermittently over any extended period of time, without disconnecting them, it is recommended that they be properly covered with canvas or some water-proof covering.

(8) "When instruments are being carried for any distance leather carrying cases made to fit are recommended.

(9) "The packing of instruments for transportation should be given careful consideration, and whenever they are shipped for any great distance they should be packed in excelsior after being carefully wrapped in paper. Excelsior absorbs the vibration better than any other packing material.

(10) "When instruments are carried on trains, trolley cars, or in automobiles, it is not good practice to allow them to rest on the floor or on the seat unless it is provided with a cushion. Excessive vibration is liable to damage any instrument in time. If no cushions are available it is better to carry them in the lap unless packed in a box containing excelsior.

(11) "Always lift the instruments and never allow them to slide on their rubber supports.

(12) "Polishing wooden meter cases occasionally with some good furniture polish will assist in keeping them in first-class condition. The better the appearance of an instrument, the more care is applied in handling and using it." M. W. G.

The Quantitative Determination of Palladium by Means of 6-Nitro-quinoline. S. C. OGBURN AND A. H. RIESMEYER. *J. Am. Chem, Soc.*, **50,** 3018–22 (1928).—Palladium may be quantitatively precipitated from a chloride solution by means of a saturated solution of 6-nitro-quinoline. By use of the gravimetric factor 0.2345, the percentage of palladium may be had by direct weighing of the precipitate. The reagent does not react with other metals of the platinum group and hence may be used in effecting both the separation and determination from these metals. A. P. B.

Some Notes on the Determination of Aluminum. With Special Reference to the Use of Hydroxyquinoline as a Reagent. W. SINGLETON. *Chem. Age, Mo. Met. Section*, **19,** 25 (Oct. 6, 1928).—Hydroxyquinoline precipitates aluminum as a crystalline, greenish yellow ppt. with the formula $Al(C_9H_6ON)_3$. The Al ppt. differs from the quinoline salts of Ca, Mg, Zn, and Cd by being readily soluble in NaOH solutions and, unlike that of Mg, may be obtained in the presence of dilute acetic acid. The ppt. may be weighed after drying at 110°C., or it may be ignited together with oxalic acid and finally weighed as alumina, Al_2O_3. The hydroxyquinoline ppt. may also be accurately and quickly determined by titration with 0.1*N* bromate-bromide solution. Full details and various applications of method are given. M. W. G.

Studies on the Periodic System. I. The Ionic Potential as a Periodic Function. G. H. CARTLEDGE. *J. Am. Chem. Soc.*, **50,** 2855–63 (Nov., 1928).—One of the serious defects of the Mendeléeff system of classification of the elements is that it has no quantitative basis. More recent modifications have placed emphasis upon atomic structure as the basis of classification. All forms of classification, however, suffer from the difficulty that the elements have too protean a nature for any one characteristic to be used as the basis. It is highly desirable that there be a periodic arrangement devised which will be quantitative and which will provide a place for all valence forms of all elements. The author proposes an arrangement which takes account of the charge, structure, and radius of the ions, and from which properties he derives a new function, the ionic potential. It is shown that the new arrangement satisfactorily represents the behavior of hydrogen, the eighth group elements, and the rare earths. It is also shown that the properties of the ions are definitely related to the structure of their outermost electronic shells. On this basis a new definition of the periodic families is given. A. P. B.

Studies on the Periodic System. II. The Ionic Potential and Related Properties. G. H. CARTLEDGE. *J. Am. Chem. Soc.*, **50,** 2863–72 (Nov., 1928).—A continuation of the above paper relating various properties of ions to the ionic potential. A. P. B.

The Color of Iodine Solutions. F. H. GETMAN. *J. Am. Chem. Soc.*, **50,** 2883–90 (Nov., 1928).—"The dependence of the color of solutions of free iodine upon the nature of the solvent has been the subject of numerous investigations, but notwithstanding the thoroughness of these studies the problem of the exact composition of iodine solutions remains yet to be solved completely." A brief review of the literature is given. Lachman, after examining solutions of iodine in more than 60 carefully purified solvents, representing 12 types of organic compounds, concluded that saturated solvents yield violet solutions, whereas solvents having an unsaturated character yield brown solutions. The author measures the extinction coefficients of solutions of iodine in 12 solvents at

intervals of 10 mμ through the visible spectrum from 680 mμ to 430 mμ. Saturated compounds as solvents yielded solutions with absorption maxima ranging from 520 mμ to 540 mμ. Unsaturated compounds, on the other hand, yielded solutions having absorption maxima ranging from 460 mμ to 480 mμ. Some of the solutions were exposed to ultraviolet radiation. Their behavior appeared to confirm the view of Lachman that unsaturation in the solvent is a factor of considerable importance in determining not only the color but also other properties of iodine solutions. A. P. B.

Chemical Books. EDITORIAL. *Chem. & Ind.*, **47,** 1109 (Oct. 26, 1928).—Concentration of the chemical industries under a relatively few large organizations is partially blamed for the decrease in the number of books and journal articles dealing with industrial processes. A brief list of recent English chemical publications is given. E. R. W.

Removing Dried Ink from Vulcanite Fountain Pens. R. DITMAR. *Chem.-Ztg.*, **52,** 123 (1928); *C. A.*, **22,** 4209 (Nov. 10, 1928).—"The greenish gray discoloration caused by prolonged immersion in water or aqueous solutions to remove dried ink may be avoided by using a solution of $Na_2S_2O_4$, which effects a rapid cleaning without affecting the vulcanite." M. W. G.

KEEPING UP WITH CHEMISTRY

Radium and Geology. C. S. PIGGOT. *J. Am. Chem. Soc.*, **50,** 2910–6 (Nov., 1928).—The general problem of the relation of radium to geology has three main subdivisions: (1) the determination of the radium content of, and its distribution throughout, the lithosphere, and possibly an estimation of the amount and distribution throughout the earth; (2) the heat energy made available for the melting of the sub-crystal structure and its rôle in mountain building; (3) the radioactive disintegration of uranium into lead and its application to the determination of geologic time. A method for the determination of radium in ordinary rocks is outlined and the radium content of seven representative granites of the eastern seaboard of the U. S. given. The second problem is discussed briefly. A direct experimental means of determining the uranium and uranium-derived lead involved in an age determination is given, and the relative preponderance of the isotopes of lead in such material discussed. A. P. B.

New Mill of Colorado Portland Cement Company Model of Its Kind. C. H. VIVIAN. *Compressed Air Mag.*, **33,** 2595–601 (Dec., 1928).—An interesting illustrated description of the manufacture of Portland cement by the dry process. This article should prove to be good supplementary reading for students of elementary chemistry as well as for those in more advanced classes. E. R. W.

Photoelectricity. SIR WILLIAM BRAGG. *Sci. Mo.*, **27,** 522–30 (Dec., 1928).—A discussion of the nature of light including certain experimental evidences in support of the corpuscular theory. When we see, says B., that radiation, which has always been thought of as undulatory, can on occasion display corpuscular properties, we are prompted to ask whether moving electrons—beta rays, cathode rays, and so on—which we have always considered as corpuscular, may not behave sometimes like waves? C. W. S.

Hypon—A Hypothetical Element and a Possible Source of Stellar Energy. W. S. ANDREWS. *Sci. Mo.*, **27,** 535–7 (Dec., 1928).—In an attempt to explain the source of energy that is continuously radiated into space by our sun and other stars A. assumes a new element, hypon (atomic number, 118) belonging to the zero group. It is radioactive and on account of its great size and complexity of its atoms, it should possess this property in a superlative degree. Its activity, however, is greatly reduced by the tremendous gravitational pressure of its environment. Its activity is so regulated by this pressure that only sufficient energy is liberated to maintain the sun's radiation. If the radioactivity of hypon is influenced by pressure, it follows that as pressure decreases the activity will increase and at certain minimum pressure its atoms will spontaneously disintegrate and form other lighter atoms. This disintegration will necessarily be explosive. On the basis of this, A. attempts to explain the evolution of temporary stars or "novas." G. W. S.

Potash. J. W. TURRENTINE. *Mineral Ind.*, **26,** 477–90 (1927); *C. A.*, **22,** 4728 (Nov. 20, 1928).—"The industry in the U. S. and foreign countries is reviewed." M. W. G.

The Bromine Industry in Alsace. C. HORST. *Chim. et Ind.*, **Special No.,** 404–5 (Apr., 1928): *C. A.*, **22,** 4208 (Nov. 10, 1928).—"Brief outline of the process of extraction of Br in the Alsatian potash mines and of its possibilities of development with increased Br demand in the chemical industry." M. W. G.

The Nitrogen Industry. R. E. SLADE. *J. Soc. Dyers Colourists*, **44,** 265–8 (1928); *C. A.*, **22,** 4208 (Nov. 10, 1928).—"A review is made of the development of the N in-

dustry of the world. Some details of the process of N fixation used by the Synthetic Ammonia and Nitrates, Ltd., at Billingham are given. This factory, which represents the British N industry, uses the Haber process with a pressure of 200 atms. The output is 235 tons of NH_3 per day. This is converted chiefly into $(NH_4)_2SO_4$ by means of the gypsum process which yields a chalk by-product of use in agriculture and in the cement industries." M. W. G.

Copper in Antiquity. C. H. DESCH. *Nature*, **122**, 886 (Dec. 8, 1928).—This is an excerpt from a report by Prof. C. H. Desch of the British Association Research Committee, who is investigating the source of early Sumerian copper. The report is of interest as it shows the very early use of bronze. The analysis of three specimens of bronze from a grave at Ur, dated about 3500 B.C., are as follows:

	A	B	C
Cu —	84.18	85.13	85.01
Tin —	12.00	11.78	14.52
Pb —	1.62	1.12	0.47
Ni —	2.20	0.25	trace
Fe —	.....	1.71	.....

The sheet metal from the Egyptian statute of Pepy contained 1.06 nickel. Other analyses show that small amounts of nickel occurred occasionally in other bronzes. The problem of the British committee was to find the probable source of these ores. A copper ore containing nickel occurs at Jabal al Ma'adan in Wadi Ahin, inland from Sohan in the State of Oman. This might be the site of Magan referred to by Sargon in his geographical table, and mentioned in the time of Judea in the lists as one of the places from which came ships and copper. The Transvaal has nickel-bearing copper ores, and an ancient bronze object from there contained 3% nickel. T. B. D.

Printing Inks. ANON. *Chem. & Ind.*, **47**, 1147–9 (Nov. 2, 1928).—A description of the various classes of printing inks. The preparation and methods of mixing the ingredients is briefly outlined. E. R. W.

Capillarity in Connection with Dyeing. R. CAMERON. *Dyestuffs*, **29**, 149–50 (Oct., 1928).—A discussion is given of the part that capillarity takes in dyeing. A. E. C.

Hydrogen-Ion Measurements in the Pulp and Paper Mill. W. F. HOFFMAN. *Dyestuffs*, **29**, 172–6 (Nov., 1928). A. E. C.

Welding Monel Metal and Nickel. C. A. CRAWFORD AND J. G. SCHOENER. *Inco*, **8**, 11–2, 14 (1928).—The fixed composition alloy, Monel metal, is contrasted with nickel in its general properties in the introductory paragraphs of the paper. Two characteristics of particular interest to those attempting to weld these metals are: their high melting points, above 2500°F., and their tendency to "pass through a pasty condition between the solid and liquid state" correspondingly increasing the difficulty of fusing the joined parts of the metals to be welded.

"Monel metal and nickel can be welded by practically all standard commercial methods." In these "standard methods" are listed oxy-acetylene, metallic arc, carbon arc, spot welding, line welding, and even electric butt-welding by the aid of a special technic.

In welding with the oxyacetylene torch a very slight excess of the fuel gas, never in an excess of the oxygen, may be used. The flame must be made to cover the parts being fused at all times to prevent access of air with its oxidizing oxygen. The flux suggested for use is made of a mixture of borax crystals, boric acid crystals, and sodium silicate. Other commercial fluxes are suggested.

Seam welding is usually accomplished along a flange. On the reverse of the flange is a crevice which is very likely to need a "fill." This is usually accomplished by brazing or by silver soldering. Such hard-solder alloys and their compositions are discussed and their susceptibilities to corrosion are pointed out. Suitable fluxes for this work are also described. B. C. H.

Vitamins and Sunlight. L. HARRIS. *Discovery*, **10**, 16–7 (Jan., 1929).—Progress in the study of vitamins, in particular from the work at Cambridge, has lately been of marked significance, but much remains to be discovered about these essential substances. There is not yet sufficient evidence for many of the loose statements that sunlight and vitamins are equivalent. Vitamin D as an anti-rachitic agent, and good hygienic living conditions are compared, and the experiments made in Vienna just after the war under the guidance of Dr. Harriette Chich are cited to give evidence to support two prevalent hypotheses relating to the treatment of rickets. Mention is made of the discovery that cholesterol, preferably the impurity in this substance called ergosterol, both contained

in cod-liver oil, may be activated by exposure to sunlight so as to be more potent than cod-liver oil itself in the treatment of rickets. Irradiated ergosterol is now on the market as "Radiostol" and "Vigantol." It seems to be a fact that it is the ergosterol in the skin which exposed to sunlight develops anti-rachitic properties.

Another vitamin present in green shoots of plants is vitamin A. Dr. Thomas Moore has shown that shoots grown in the dark (etiolated) are just as rich in vitamin A as those grown in sunny places. In many cases therefore there is no scientific basis at all for the loose statements which are made that sunlight and vitamins are equivalent. It is only in the case of vitamin D that a relationship has been shown to exist. J. H. G.

HISTORICAL AND BIOGRAPHICAL

The Second Century of Aluminum. *News Edit., Ind. Eng. Chem.*, **6,** 1 (Nov. 10, 1928).—A brief account of Hall's work on aluminum and notes on the exercises held recently in Oberlin, when a tablet was placed upon the house in the woodshed of which Hall completed his work. Illustrations. M. W. G.

The History of the Bunsen Burner. HEINRICH BILTZ. *Z. angew. Chem.*, **41,** 112 (1928); *C. A.*, **22,** 4010 (Nov. 10, 1928).—"Feldhaus (*C. A.*, **22,** 335 (1928)) states that independently of Bunsen and at about the same time (1851, 1854) R. W. Elsner invented a burner like that of Bunsen. However, a burner in which air was mixed with gas to prevent soot formation was described by Faraday in 1828. Thus the principle of the Bunsen burner goes back to Faraday; to Bunsen belongs the credit for its present form." M. W. G.

New Views of Pasteur Memorial, Chicago. *Hygeia*, **7,** 45 (Jan., 1929).—Four photographs. M. W. G.

Ira Remsen, 1846–1927. JAMES F. NORRIS. *J. Am. Chem. Soc.*, **50,** 67–80 (Nov., 1928).—A biographical sketch with special emphasis placed upon Professor Remsen's research work and contributions to chemical theory. A. P. B.

The Centenary of Wöhler's Synthesis of Urea. A. WOHL. *Z. angew. Chem.*, **41,** 897–902 (1928). M. W. G.

Justus Liebig as the Founder of Agricultural Chemistry. F. HONCAMP. *Z. angew. Chem.*, **41,** 463–7 (1928). M. W. G.

Instrument Pioneers. GEORG SIMON OHM (1789–1854). *Instruments*, **1,** 503–5 (Dec., 1928).—A short biographical sketch with portrait. M. W. G.

THE METHODS AND PHILOSOPHY OF EDUCATION

Another Attempt to Teach How to Study. R. STRANG. *Sch. & Soc.*, **28,** 461–6 (Oct. 13, 1928).—A number of students whose failure in one or more subjects was apparent were required by the administration to drop the doubtful subjects and to substitute a "how to study" course. The substitution of a course carrying no credit naturally met with considerable opposition on the part of the students.

Many difficulties were encountered in an attempt to formulate a course in methods of study because of individual differences and the lack of a clear understanding as to what constitutes effective study habits. Reference is made to investigations by authorities of methods used by successful students. K. S. H.

The Place of the Serious Student in Civilization. P. W. L. COX. *Sch. & Soc.*, **28,** 502–5 (Oct. 27, 1928).—Ours is a machine civilization, says the writer in his Honors Day Address at the Univ. of Arkansas.

Reference is made to the education of young adults in the Danish Folk High-School with the suggestion that the American Liberal Arts College be organized on a similar basis.

In the past it has been largely the leisure class which has developed and encouraged certain accepted traits. Though youth for the most part has indulged in those things which require little mental effort, fortunately there have been some who have made use of the opportunities which have been theirs

Much progress has been made and a high degree of loyalty established in colleges whose student councils or other groups have been allowed to survey their institution. Many colleges discourage initiative, investigations, and the student's right to inquire and to challenge. This is the reason for such educators as are mentioned by the author "doubting that education can ever aid in the advancement of civilization."

The world will advance only as our colleges see the needs of our present-day students and extend to them the opportunities which should be theirs. A college as a traditional institution contributes little to progress. K. S. H.

Educational Work. W. H. PYLE. *Sch. & Soc.*, **28,** 590–1 (Nov. 10, 1928).—

Expensive is the wasteful education of our present-day schools. Wasteful, the author claims, because of the many useless things which are taught. A child should come to know the use and value of those things which lie about him and thus through his 12 years of school life gain a knowledge that will become effective in his life and contribute to his happiness. K. S. H.

A New Type of Junior College. EDITORIAL. *Harvard Alumni Bull.*, **31,** 64–5 (Oct. 11, 1928).—In Bronxville, New York, there is a new and interesting collegiate institution called the Sarah Lawrence College. It is a junior college for women which opened its doors in the fall of 1927 and stands for a relatively novel and very definite type of collegiate instruction. The distinguishing feature of the Sarah Lawrence College is not a "method," nor any mechanical feature or plan of organization or administration; it is a matter of emphasis throughout the work of the institution. The College proposes to use its entire energy and every means at its disposal to cultivate the taste of its pupils and develop their powers of appreciation; and to this end it gives up completely the idea that they should have vigorous training in the technic and ideals of pure scholarship as these are commonly understood in "regular" colleges. Intellectual effort is not to be neglected; the student's curriculum is to be well balanced; the requirements for admission and for graduation are in no sense inferior to their demands on the student's time and abilities: but the work of the college is not directed toward the solution of technical problems through a mastery of data scientifically handled, but toward the consideration of values and the formation of personal attitudes and habits. Activities that are relegated in other institutions to the category of "extra curricular" effort are to be organized at Sarah Lawrence as a part of the student's plan of life, and the whole program of study and play and work is to be fused into a single continuing process. S. W. H.

Schools for the Unscholarly. EDITORIAL. *Harvard Alumni Bull.*, **31,** 300 (Dec. 6, 1928).—Modern studies of intelligence, which have been greatly stimulated and favored by the invention of standard psychological tests and that extremely handy tool of psychological and educational research, "the intelligence quotient," have gone through a period in which they tended to emphasize the importance of verbal mentality, or word-mindedness, and are only recently beginning to recognize the possibility and value of the types of mind and other "styles" of mental reaction. The burden of Professor W. F. Dearborn's recent book, "Intelligence Tests: Their Significance for School and Society," is on the one-sidedness, and indeed unfairness, of the American educational scheme and the tests used for determining fitness for educational advancement. Professor Dearborn believes that provision should be made for boys and girls who are limited in their power to use words cleverly and effectively, but may have a substantial perception of meanings and values and no little power for productive work and social leadership. Many may find their best mode of expression in handling things, not words, or in the use of lines, shades, and colors, or sounds and rhythms. S. W. H.

Intellectual Coöperation. QUOTED FROM *The British Medical Journal. Science*, **68,** 547 (Nov. 30, 1928).—The Institute of Intellectual Coöperation, an offspring of the League of Nations, is headed by Professor Gilbert Murray and located in Paris. Interchanges of professors and students between universities of different countries has been encouraged as well as interchange of secondary school teachers. The question of traveling or exchange scholarships is under consideration.

"An attempt is being made to bring libraries and universities of all countries into a scheme of coöperation whereby scientific or bibliographical information may be made mutually available. Another enterprise aims at the removal of undue hindrances, in the shape of customs barriers and postal tariffs, to the international distribution of books." G. H. W.

Educational Gluttony. EDITORIAL. *Penna. Gaz.*, **27,** 293 (Jan. 11, 1929).—During the past century, particularly during recent decades, greater emphasis has been forced on education by the massive weight of public opinion. Wholesale and compulsory education in its intended effect is the most socialistic practice conceivable in the practical world. "All men are born free and equal." Legislation contrary to natural laws is futile and ridiculous. By reason of heredity no two men are born equal, so how could a hundred million be so? The colleges are *squeezed* with men who, by nature, were not destined for education, and in defying nature we injure the individual and the nation. The colleges are realizing this more and more and the situation is improving. The article on "The Evils of Standardized Education" by C. W. Burr, appearing in April, **1927,** *Gen. Mag. & Hist. Chron.* is quoted. Is it a heresy to suggest that many of our citizens should be taught only to read and to write? Those men whose capacities are definitely limited should not have visions of glory and power flaunted teasingly before their

puny intelligence. Science finds these men and reveals what a huge number exists. Why should we not lay aside deceiving socialism and complacent smugness? We cannot all be Caesars. J. H. G.

Research and Other Intellectual Activities. P. B. MCDONALD. *Bull. Am. Assoc. Univ. Profs.*, **14**, 528–30 (Nov., 1928).—Research has suffered in some universities by being confined strictly to *contributions to knowledge* published in the formal style. Too many contributions to knowledge printed in research journals are described as "never heard of afterward" and too often "tasks of benefit to the researcher but to nobody else."

Over against these formal productions commonly labeled "contributions to knowledge" are "new interpretations" which deserve to be characterized as "scholarly achievements." In a similar classification should be listed "critical syntheses of scattered or ill-understood facts" and "useful liaisons between sciences and subjects hitherto kept purely apart."

The plea is made that both types of scholarly productivity should be recognized by college and university administrators. Combing the field for "new knowledge" should be encouraged to continue but quite as important is the work of "philosophical scholars," who interpret the "new knowledge" by synthesizing it into the "old." These should not be penalized by a university policy of recognition based solely upon quantity publication. For it must be recognized that these scholars are "not so ready at producing a large number of research titles in a short space of time."

The further contention is made that the function of a university covers, not only the "discovery and publication of new truths, but the caring for a constant need of adapting and adjusting these truths for succeeding generations of students. B. C. H.

The Teaching of Chemistry in Small Colleges. LEO P. SHERMAN. *Chem. Bull.*, **15**, 362–3 (Dec., 1928).—A brief account of the advantages of the small college chemistry courses over those in the larger institution is offered in this paper. The chief advantages listed are: smaller classes permit a more efficient teaching since lecture, class, and laboratory work are all in charge of the same teacher. More intimate personal acquaintance between teacher and pupil is also cited as an asset hardly attainable in the larger institution. The contention is made that the teacher in the small college is more interested in the teaching side of his job than is true of the instruction in larger institutions where much of this work is done by graduate assistants primarily interested in course or investigational work.

Courses offered in the small college are enumerated as: general chemistry, two courses, one for those who have had no high-school chemistry and the other for those who have; qualitative analysis, one semester; quantitative analysis, one semester; organic chemistry, one year; and physical chemistry, "of a semi-research nature." B. C. H.

Organizations. W. A. NOYES, JR. *Chem. Bull.*, **15**, 368–9 (Dec., 1928).—"The American citizen who does not belong to a few college fraternities, at least one honorary society, one or two lodges, a couple of professional societies, a church club (and) an alumni association. . . . . is distinctly behind the times. In addition . . . . . every respectable citizen is supposed to be taking a part (or at least contributing) in some sort of drive . . . . . or other worthy cause. It is quite possible for the individual to participate in (such organizations) . . . . to the point of diminishing returns both to himself and his value to the community. A more moderate indulgence for office or for taking an active part in (so) many movements . . . . would give many the time for contemplative reading and reflection which seems so woefully lacking in American life at the present time." B. C. H.

Participation of State Teachers Associations in Educational Legislation. A. L. MARSH. *Wash. Educ. J.*, **8**, 74–5 (Nov., 1928).—Educational legislation is the business of the public rather than of the teaching profession. The counsel of the profession regarding educational legislation should be really expert, and professional counsel should be tendered with tact and propriety. In order that the professional counsel may have prestige and influence it must be unified. Ideally the state department or state association should be able to speak for both, but practically they will not always agree on major issues. Two suggestions are, first, to sell the proposal to the other before trying to sell it to the public or legislature, and second, since the state department has an advantage in counseling with the legislature and the state association with the public, the two agencies should supplement and reinforce each other. The association's legislative counsel must be mature, foresighted, and consistent. The counsel must be based on ample and dependable information. The legislative branch of service should be associated with its publicity service. The legislature is entitled to the association's counsel on educational measures and if association headquarters are not in the capital city, special head-

quarters should be maintained during sessions. The association's paid representative can best serve as a reporter. Inside service is always more valuable than outside. A discussion of favorable legislative machinery is given. A. E. C.

The Citizen and the Schools. ANON. *J. Natl. Educ. Assoc.*, **17,** 257 (Nov., 1928).—The citizen should be acquainted with the child-centered curriculum, the buildings and equipment which are needed to meet the requirements of the school program of his community, the basic principles of school finance, the administrators of his schools, and the teachers of his children. The responsibility for informing the citizen rests with pupils, teachers, and administrators. He may be informed through publications and annual reports. A. E. C.

The Newspaper and the Schools. ANON. *J. Natl. Educ. Assoc.*, **17,** 258 (Nov., 1928).—Since a majority of the readers of the newspapers are interested in school matters, newspapers should devote portions of their columns to education. Material may be gathered in small cities by the pupils or teachers. Some one of the superintendent's staff may supply official information to the press. A. E. C.

The Community and the Schools. ANON. *J. Natl. Educ. Assoc.*, **17,** 259 (Nov., 1928).—The community is brought into contact with the schools by means of organizations. The National Congress of Parents and Teachers has assumed leadership in school interpretation. A. E. C.

THE PHILOSOPHY OF SCIENCE

The Man of Science. EDWARD M. EAST. *Scribner's*, **84,** 645–53 (Dec., 1928).—The article is an effort to define the man of science—his position and limitations, and how science has taken unto itself much of the field of the older philosophy. While it does not lend itself to a short abstract, the following quotations are worth noting:

"The Creed of the Scientist upon which he believes the salvation of the world depends is simple. Deal only with facts; approach them without prejudice; draw justifiable conclusions from them; face these conclusions boldly."

The author states further: "I am inclined to think that excellence in scientific work is indicated by four things: the vigor with which the problem is formulated, the way in which non-essential variables which confuse the issue are eliminated, the homogeneity of the facts and the precision with which the facts are analyzed." . . . . "The sole objective of science is to teach the relation of things to each other. It certainly does not teach the true nature of things."

In other words, one should differentiate in values between the accurate statement of observed phenomena and unproved speculation regarding their origin or nature.

T. B. D.

Science and the Educated Man. HERMAN RANDALL, JR. *Bull. Am. Assoc. Univ. Profs.*, **14,** 531–4 (Nov., 1928).—A liberal education should give: some understanding of the world into which we are born; some knowledge of the natural span of human life and of the biological organism which is man. It should place in man's hand the best intellectual technic for understanding himself and his world. The most potent instrument ever discovered for attaining these ends "is that body of organized methods and technic we call science."

Concepts and methods of science have been "the radical intellectual force of the last three centuries" yet our best college students "can graduate with distinction without ever having come closer to science than vague allusions and meaningless generalities." Those students who have ventured into its courses have usually acquired a dislike for its rigorous drill often conducted by "cook-book," "follow-the-directions" methods with no rewarding glimpse of the meaning of it all until after years of exacting grind upon fundamentals."

"Unless scientists are willing . . . . (to humanize) their own subjects . . . . science will go the way of the classics as a part of a liberal education."

"There is no reason why every student should not learn something, at least, of the spirit of scientific thinking, of its significance in our civilization, of the meaning and implications of some of the basic concepts and methods that have been worked out . . . . . A liberal education need not make scientists of students, but it should at the very least create in them a sympathetic understanding of the scientific enterprise itself."

B. C. H.

Electric Research and Progress. W. R. WHITNEY. *Gen. Elec. Rev.*, **31,** 629–34 (Dec., 1928).—After launching his address (before the fifty-first convention of the National Electric Light Association) with the sentence, "Scientific research, in its various fields, develops in one who watches it an ever-increasing appreciation of Creation," Dr. Whitney pays his respects to parents who "put counter pressure and control" upon the "intensely inquisitive and appreciative" natures of their children.

To define progress he says: "Call progress the motion away from the less helpless and satisfied state and toward the greater appreciation of indefinite new possibilities which we may easily bring within our reach." He assures his auditors "there is no danger (as yet) that an upper limit (of this progress) has been approached."

Material investigations are asserted to be productive beyond measure. But such investigations must be made from many approaches to approximate their utmost possible worth. The nature of light and the ramifications of radio are used to illustrate this. Ultimately such work always results in benefits to the public.

To give more concreteness to the evolution of the uses of a substance, as research upon it progressed, he paints a most interesting picture of the small beginnings of the industrial uses of hydrogen as a control atmosphere in metallurgical furnaces changing to more specific uses: in cutting and welding metals, as a flux in welding tungsten to steel, in the attainment of higher temperatures by aid of the atomic hydrogen arc, in cooling motors, and as an aid in fabricating transparencies for ultraviolet light.

B. C. H.

THE TEACHING PROFESSION

What Does a College Teacher Do? C. C. LITTLE AND COMMITTEE. *Bull. Am. Assoc. Univ. Profs.*, **14,** 524–6 (Nov., 1928).—The article is a setting forth of "types of action characteristic of effective teaching" by a committee of the American Council on Education. The purpose of the statements, twelve in number, is to aid in defining more clearly the teacher's work. The statements, in brief, are: (1) mastery of subjects taught; (2) organizing the content in proper perspective; (3) adjusting content to the college and its curriculum; (4) the study of his students; (5) setting student objectives for his courses; (6) striving for student self-motivation; (7) evaluation of the results of his teaching; (8) readjusting his courses in the light of such evaluation; (9) coöperating with colleges in administration activities; (10) seeking significant relationships among thoughts and things; (11) developing a coherent vision of progress; (12) creating the means of realizing such vision. B. C. H.

Our Truant Professors. ADDISON HUBBARD. *Outlook*, **150,** 1270 (Dec. 5, 1928).—The modern university has become a vast business enterprise. Among the multitude of activities required of its professors good and effective teaching is least recognized and most poorly rewarded. It is not strange that the professor is neglecting the classroom and pursuing better rewarded "extra-curricular" activities. G. H. W.

What Teachers Should Include in Letters to Food Companies. ELLEN M. WHITE. *Home Economist*, **6,** 337 (Nov., 1928).—Food companies are glad to send out educational material and this will be greatly speeded up if teachers will tell subjects they teach, number of students in class and how they intend to use the material requested. J. W. H.

Family Budget of University Faculty Members. JESSICA B. PEIXOTTO. *Science*, **68,** 497 (Nov. 23, 1928).—See following abstract. G. H. W.

$5000 a Year. EDITORIAL. *Harvard Alumni Bull.*, **31,** 333 (Dec. 13, 1928).—A recent contribution to *Science* presents for inspection the budget of 50% of the married members of the University of California faculty. The schedules of 96 householders were available. The average family consisted of 3.5 persons, and the expenditure of this fractional group averaged $5000 per annum.

Salaries alone did not provide this amount; indeed, in three-quarters of the cases salaries did not pay for the goods and services regarded as necessaries. 75% of the faculty families had to supplement professional wage with other earnings. The mean cost of living for the 96 households proved to be $5511.77; generally speaking, the professors spend $7000 and the instructors $4000.

To summarize: these families at every income level spent 17% of their budget for food, 17% for shelter, 9% for clothes, and for investments, automobiles, health, recreation, and dependents outside the home, an average of one-fourth to one-third of the total expenditure; 57% had automobiles, one-third had dependents outside the home. House operation took 13%, education took 1.5%; church, charity, and tobacco absorbed less than 1%. The standard and cost of living disclosed in this article are minimum for professional men, $5000 was the minimum cost of health and decency, yet in most cases it was obtained only by extraordinary exertions. S. W. H.

A Profession in the Making. P. TEMPLETON. *J. Natl. Educ. Assoc.*, **17,** 303–4 (Dec., 1928).—At the present time teaching is hardly a profession. Mr. Smith names four criteria of a profession. Teaching does render specialized social service. Salaries are adequate for the maintenance of a cultural standard of living, except in small towns and wide open spaces. Teachers are not all trained and tenure is hardly reasonably

permanent. However the untrained teacher is losing ground and many teachers attend summer schools. The profession is biologically handicapped as to tenure. Do teachers have professional spirit? They have at least loyalty, pride, and coöperativeness. So teaching is a profession in the making. Higher salaries, higher certification requirements, a longer period of professional training, and practice teaching and permanent tenure will help. Teachers' organizations will add virility and spirit. A. E. C.

"Externs" in Teacher Training. ANONYMOUS. *J. Natl. Educ. Assoc.*, **47**, 241–2 (Nov., 1928).—The Eastern State Normal School of South Dakota has organized a method of keeping in touch with her graduates. A director of field service visits the graduates in their classrooms and advises with them as to how problems may be solved. The aim is two-fold: to aid the teacher in adjusting her training experience to her particular position and to train normal students in a more practical manner. Details are given. A. E. C.

Mental Health through Growth. D. W. LA RUE. *J. Natl. Educ. Assoc.*, **17**, 274 (Dec., 1928).—To make the most of yourselves you can do two things. Form an ideal, which is largely individual. Check up your fundamental tendencies and find out what kind of a person Nature intended you to be. Teachers should have the qualities of kindness, poise, comradeship, and a sense of humor. The common failure in discipline is first of all a failure in self-discipline. In growing to your ideal, use each of the primary emotions to facilitate or inhibit each of the others. Finally, practice the trait under actual living conditions. A. E. C.

THE CONSUMERS' CLUB

How a book may develop into an institution is illustrated by the history of the Consumers' Club, 2 West 43rd Street, New York City, an outgrowth of "Your Moneys' Worth" by Stuart Chase and F. J. Schlink. "Kindly tell me the name of the vacuum cleaner mentioned on page 255," wrote some readers; or "How may we secure the benefits of the White Plains Experiment mentioned on page 254?" In sheer self-defense the authors, who were responsible also for this Experiment, had to reorganize it as the Consumers' Club so as to take care of inquiries from all over the country.

Members of the Club pay $2 a year and receive on request expert opinion about some of the articles of everyday life. Commodities are listed by their brand names in two columns, one giving those which represent, in the opinion of certain testing agencies and technical experts, good value at their price. In a parallel column appear commodities, also by name, which are not recommended, either because they cost too much, quality considered; or because they are not so suitable as other commodities in the same field; or because the technical committee considers them misadvertised; or because the manufacturer does not give good service in replacing or repairing defective goods.

A sponsoring committee consisting of prominent economists, engineers, lawyers, editors, and others is being organized in the interest of the consuming public, so as to make perfectly evident the good faith and lack of commercial motive on the part of those who make the technical recommendations. Thus the consumer is assured that here at last is an attempt to judge things from his own point of view. In the opinion of one well-known member, it is "the most important organization that has been formed in recent years to control economic activity."

Local Activities and Opportunities

Through these columns, the JOURNAL desires to render a two-fold service.

1. Local Activities. Keeping its readers in touch with the varied interests of institutions, A. C. S. sections, teachers' asssociations, and other organizations throughout the country. Items of general interest would include: (1) notices of local scholarships or fellowships; (2) notices of any special gifts to chemical organizations or departments—as fellowships, endowments, laboratory gifts, library gifts, etc.; (3) accounts of meetings, social functions, exhibitions, chemical entertainments, etc., which might be suggestive to other organizations (where original or unusual features are included it is desirable that they be described in some detail); (4) news notes concerning persons of sufficient prominence in their respective fields to make their movements of general interest; (5) promotions within, or changes of, personnel of a department; (6) announcements of new or unusual courses in chemical education or special fields of chemistry; (7) notes on new chemistry buildings or laboratories, stressing the unique features.

2. Opportunities. Providing an exchange column for positions. That is: (1) any teacher who is a subscriber to the JOURNAL, desiring to change his position, may advertise once a year without charge (correspondence will be handled through the editorial office, if desired); (2) any notices of vacancies, in which chemistry teachers and chemists will be interested, will also be published.

The responsibility of reporting items for this section rests entirely with the local institutions and organizations. It would be desirable to have some person connected with each organization and institution appointed to report regularly.

Suitable material sent to the editorial office before the 20th of each month will be published in the following month's JOURNAL. The Editorial Staff must necessarily reserve the right to abridge or totally reject any items submitted. If the above suggestions are followed, however, the necessity for such action will be largely obviated.

Haverford College. Dr. Ellice McDonald, Chief of the Cancer Research Institute, Philadelphia, recently addressed the Scientific Society of Haverford College on "Cell Division and Its Relation to Cancer Study," showing his moving pictures illustrating divisions of normal and cancerous cells.

Mr. Arthur F. Gallaugher, formerly of the University of British Columbia, is instructor in chemistry, and Richard Wistar, a graduate of the college, is assistant in chemistry, for the current year.

Pennsylvania State College. Dr. Frank Clifford Whitmore has been appointed Dean of the School of Chemistry and Physics at the Pennsylvania State College, effective July 1, 1929. He assumes his new position after having been for four years head of the department of chemistry at Northwestern University, Evanston, Illinois, where he has been a member of the Chemistry Department since 1920. Dr. Whitmore succeeds Dean G. L. Wendt, who has been appointed Assistant to the President of the College in Charge of Research.

Dr. Whitmore has taught at Harvard University, Williams College, the Rice Institute in Houston, Texas, and at the University of Minnesota. He is a Director of the American Chemical Society and was Director of the Second Session of the Institute of Chemistry held at Northwestern University last summer. During the year 1927–28 he was Chairman of the Division of Chemistry and Chemical Technology of the National Research Council. He is a member of the Advisory Board to Major General A. A. Fries, Chief of the Chemical Warfare Service, United States Army, and a Collaborator in the Bureau of Chemistry and Soils of the United States Department of Agriculture.

Western Reserve University. The summer session of Western Reserve University will be held June 24–August 2, 1929. The aim of the session is to be of the greatest possible service to any who wish to take work toward their degrees during the summer months, especially to those teachers who desire, by taking advanced courses, to increase their professional usefulness.

The tuition is $7.50 for each semester hour of credit. Visitors' and laboratory fees are extra. For information and bulletins write to The Registrar, School of

Education, 2060 Stearns Road, Cleveland, Ohio.

College of the City of New York. Professor Robert W. Curtis addressed the Baskerville Chemical Society on "Distinguished Scientists I Have Met," December 23, 1928.

Professor Benjamin Harrow presented a paper before the Society for Experimental Biology and Medicine, dealing with the subject of Hormones, January 16, 1929.

Dr. A. Lahrman spoke to the phase-rule class at Columbia University on "Binary and Ternary Systems of Sulfuric Acid, Nitric Acid, and Water," January 15, 1929.

The annual dinner of the Baskerville Chemical Society, Alumni Section, was held on December 15, 1928. Among the speakers were Professor Prager, Retiring President, Professor Breithut, incoming President, Professor Harrow, Professor Bacharach of Fordham University, and Dr. Marks Neidle. The speeches ranged from humorous reminiscences to the consideration of professional problems. A highly interesting letter from Professor Moody was read at the dinner.

Dr. Benjamin Harrow has been promoted to the rank of assistant professor.

Dr. Leo Lehrman has been promoted to the rank of instructor.

A new chemical organization has been formed at the College of the City of New York to be known as the Society of Chemical Engineers. Its purpose shall be to bring its members into closer contact with the actual operations in the field. To accomplish this, prominent men of chemical industry will be invited to address the Society on their specialties. The new organization has already started its program. On December 20th, Dr. L. V. Redman, Vice-President of the Bakelite Corporation, addressed the Society on "The Recent Developments in the Chemistry and Technical Applications of Bakelite."

Columbia University. Professor Marston T. Bogert has just returned from a brief lecture tour of Virginia where, in response to invitations extended by the institutions concerned, he lectured upon various aspects of the organic chemistry of perfumes as follows: on January 10th at the University of Virginia, Charlottesville, under the auspices of the department of chemistry; on January 11th, at the University Club, Richmond, Virginia, as the guest of the University Club and of the Virginia Section of the American Chemical Society; and January 12th at Hollins College, Hollins, Virginia, as speaker at the meeting of the Southwest Virginia Club of the Virginia Section, A. C. S.

Summer Courses in Chemical Microscopy at Cornell University. The department of chemistry at Cornell will offer instruction in chemical microscopy during the coming Summer Session of the University. The equipment of the Baker Laboratory is unique in this field, and affords unsurpassed facilities for the study of instruments and methods used in chemical and industrial microscopy. Two courses will be offered which will be the full equivalent of those given during the regular college year; they may be taken separately or together, or other work in the department may be carried on according to the needs of the student.

Fundamental principles and technic will be covered in the introductory course: the manipulation of the microscope and its accessories, microscopic measurements and quantitative analytical methods, crystal studies and physico-chemical phenomena, refractive index determinations, and examinations of textiles, papers, and other industrial materials, as outlined in THIS JOURNAL, **5**, 548 (May, 1928). A course in microscopic qualitative analysis, including the manipulative methods and reactions of the commoner metals and acids, will also be given.

The summer session opens July 6th, and continues for six weeks, but persons not desiring university credit may arrange to cover, in a shorter period, those portions of the work most suited to their special needs. Any inquiries should be addressed to Prof. C. W. Mason, who will have charge of the courses.

Lexington Section, A. C. S. The 131st meeting of the Lexington Section of the American Chemical Society was held in the Physics Lecture Room of the University of Kentucky, January 15th.

On this occasion, Dr. George D. McLaughlin, Director of the Research Laboratory of the Tanners' Council at the University of Cincinnati, spoke on "The Scientific Principles of Tanning." The lecture was illustrated by colored microphotographs.

Cincinnati Section, A. C. S. The 303rd meeting of the Cincinnati Section of the American Chemical Society was held in the Chemical Auditorium of the University of Cincinnati on January 9, 1929, at 8.00 P.M. Professor George D. McLaughlin, Director of the Research Laboratory of the Tanners' Council at the University of Cincinnati, spoke on "Some of the Scientific Principles of Tanning."

American Cyanamid Company is pleased to announce that beginning July 1, 1929, Dr. Firman E. Bear, of the Ohio State University, will be associated with the Company at its home office, 535 Fifth Avenue, New York City, in the capacity of Director of Agricultural Research.

Award of American Association for the Advancement of Science. For his work in an investigation of the ductless glands and particularly in his isolation of pituitary hormones Dr. Oliver Kamm, director of chemical research of Parke, Davis & Company, manufacturing chemists, has been awarded the $1000 prize by the American Association for the Advancement of Science for the "most noteworthy contribution to science presented at the annual meeting."

Some 2000 scientists delivered addresses at this meeting, which was held in New York December 27, 28, 29, 1928. The award was announced on January 2nd by Dr. Henry Fairfield Osborn, president of the Association.

The isolation of two hormones from the posterior lobe of the pituitary gland, as revealed by Dr. Kamm, is held by chemical scientists to be equal in importance to the isolation of insulin and the discovery of adrenalin.

Dr. Kamm isolated the alpha and beta hormones of the posterior pituitary after twelve years' work in the Parke-Davis Research Laboratories. This, incidentally, is the first time that any one has demonstrated that one gland might contain more than one hormone.

Parke, Davis & Company. Dr. A. William Lescohier has been appointed general manager of Parke, Davis & Company, according to an announcement made public on January 10th, by Oscar W. Smith, president of the company. Dr. Lescohier has been connected with the company for the past twenty years and has most recently occupied the position of assistant to the president. After graduation from the Detroit College of Medicine in 1909 he entered the company's employ as a member of its scientific research staff. In 1918 he was placed in charge of the production of serum, vaccines, antitoxins, and other biological products. In 1925 he became director of the department of experimental medicine, and in that capacity was in constant touch with physicians and scientific workers in the leading hospitals and medical colleges of the country.

The company also announces the appointment of Dr. Louis Klein as promotion manager and Mr. Ralph G. Sickels as advertising manager. Both men have been connected with the company for a number of years, Dr. Klein as manager of the department of medical services, and

Mr. Sickels as a member of the advertising staff.

NINTH ANNUAL OHIO STATE EDUCATIONAL CONFERENCE, APRIL 4, 5, 6, 1929

Program of the Out-of-State Speakers

Arthur J. Klein, U. S. Bureau of Education, Washington, D. C. "The Relation of the Adult Education Movement to Established Higher Educational Institutions." (Adult Education Section.)

Gerrit A. Beneker, Truro, Cape Cod, Mass. "Art and Education." (Art Section.)

Joseph Jastrow, New School for Social Research, New York City. (Attendance Supervisors, School Nurses, and Visiting Teachers.)

C. Stuart Gager, Director, Brooklyn Botanical Garden, Brooklyn, New York. "Biology and the Public." (Biological Science.)

Edmund Prince Fowler, New York. "Prevention and Management of Deafness in the Schools." (City Superintendents.)

J. O. Malott, Bureau of Education, Washington, D. C. "An Appraisal of Commercial Education." (Commercial Education.)

C. L. Rhoade, County Superintendent, LaPorte, Ind. "Evaluating Education in Terms of Rural Needs." (County Superintendents.)

J. E. Butterworth, Cornell University, Ithaca. "The Village and Consolidated Principalship in Its Relation to the County Superintendency." (County Superintendents.)

Paul T. Rankin, Detroit Public Schools. "Listening Ability—Its Importance, Development and Measurement." (Educational and Intelligence Tests.)

George R. Johnson, St. Louis Public Schools. "Administrative Problems of Testing in City Schools." (Educational and Intelligence Tests.)

Arthur I. Gates, Columbia University, New York. "Formal and Informal Testing of Educational Attainments." (Educational and Intelligence Tests.)

B. R. Buckingham, Harvard University. "Getting Objective Data When Visiting a Classroom." (Elementary Principals.)

George R. Johnson, St. Louis Public Schools. "Testing as a Function of Teaching." (Elementary Principals.)

A. Coleman, University of Chicago. "Achievement Testing." (Modern Language.)

E. H. Wilcox, University of Iowa. "Appreciation—A Chameleon in Music." (Music.)

M. Luckiesh, General Electric Company. "Artificial Light—Its Influence on Civilization." (Non-Biological Science.)

Frank C. Whitmore, Northwestern University. (Non-Biological Science.)

J. E. Butterworth, Cornell University. "Scientific Program Construction for Parent-Teacher Associations." (Parent-Teacher Association.)

E. H. Lindley, University of Kansas. "Why Stop Learning?" (Parent-Teacher Association.)

Thomas D. Wood, Columbia University. (Physical Education.)

Esther Sherman, Detroit Public Schools. (Physical Education.)

Forrest L. Knapp, International Council of Religious Education, Chicago. "Principles of Modern Religious Education." (Religious Education.)

J. S. Mullan, Sec'y, Board of Education, Rochester, New York. "The Rochester Plan of Administering School Supplies." (School Business Officials.)

Joseph Jastrow, New School for Social Research, New York. "Individual Differences in Relation to Personality." (Special Education.)

Olive A. Whildin, Supervisor of Hard of Hearing Classes, Baltimore, Maryland. "Teaching the Hard of Hearing Child." (Special Education.)

John W. Withers, New York University. "Are Our Programs of Teacher-Training Practical?" (Teacher Training.)

Arthur I. Gates, Columbia University. "New Types of Printed Materials for

Teaching Reading." (Village and Consolidated School Superintendents.)

J. S. Mullan, Sec'y, Board of Education, Rochester, New York. "The Ideal Superintendent from the Standpoint of the Business Manager." (City Superintendents and School Business Officials.)

F. N. Freeman, Chicago University. "Does Education Affect the Child's Level of Intelligence?" (Elementary Teachers.)

Dhan Gopal Mukerji, Lecturer, New York. "The India of Kipling and the India of Gandhi." (English.)

A. P. Brigham, Colgate University. "Geography as a Cultural Factor in Education." (Geography.)

John W. Withers, New York University. "The Social Challenge to the High-School Curriculum." (High School Principals.)

Mrs. Anna Garlin Spencer, Columbia University. "Parental Education for Parents and Teachers." (Home Economics.)

Gerrit A. Beneker, Lecturer, Truro, Cape Cod, Mass. "Art and Industry." (Industrial and Vocational Education.)

Arthur B. Mays, University of Illinois. "Changing Relationships in Industrial Arts and Vocational Education." (Industrial and Vocational Education.)

Rowena Harvey, South Side High School, Fort Wayne, Indiana. "High-School Publications, Bigger—But Better?" (Journalism.)

Douglas Waples, University of Chicago. "Evaluating Classroom Procedure by Means of Service Studies." (Junior High School Principals.)

Dhan Gopal Mukerji, Lecturer, New York. "The Spirit of the Jungle." (Kindergarten and Primary Teachers.)

B. R. Buckingham, Harvard University. (Kindergarten and Primary Teachers.)

Eugene Tavenner, Washington University, St. Louis, Mo. (Latin.)

E. R. Breslich, University of Chicago. "The Activities of the Class Period in Mathematics." (Mathematics.)

Ordinary Lamps Good as Neon Lights for Air Beacons. Red neon lights, suggested as beacons for airports, are not any better able to penetrate fog, as its advocates have claimed, than ordinary incandescent lamps, equipped with colored screens. This was announced recently at the International Civil Aeronautics conference in Washington, D. C., by Dr. Lyman J. Briggs, of the U. S. Bureau of Standards, in reporting on aeronautical research at the bureau. Neon lights are familiar to every one because they are used in the newest tubular advertising signs.

Tests carried out by Bureau of Standards scientists were made under actual field conditions. The neon lamp was compared with incandescent lamps so arranged that the color, size, and shape of each lamp appeared identical to the aviator.

"The test showed that there is no real difference in the fog-penetrating quality of the light from the two sources," said Dr. Briggs. "In beacons of moderate candlepower any advantages due to the distinctive color of a neon lamp may be obtained more conveniently and simply and more reliably by means of an incandescent filament lamp equipped with a suitable color screen."

As a matter of fact, putting a red filter in front of a light does not increase its fog-penetrating power, he said. Tests were also made with incandescent lamps, one of which was covered with a red screen. The lamps were both of the same power. In every case it was found that the uncovered light could be seen through a greater thickness of fog.—*Science Service*

Recent Books

Chemical Reactions and Their Equations. INGO W. D. HACKH. P. Blakiston's Son & Co., Philadelphia, Pa., 1928. Second series. x + 144 pp. 3 illustrations. 12.4 × 18.6 cm. $2.00.

This book is designed to aid the first- and second-year college students in writing chemical equations and working some of the simple problems based on the equations. It consists of six chapters, an appendix, and glossary. The chapter headings are: Symbols and Elements, Formulas and Compounds, Equations and Reactions Involving No Oxidation and Reduction, Equations and Reactions Involving Oxidation and Reduction, Reactions and Their Control, and Types of Chemical Reactions and Equations. The Appendix consists of (1) Solubility Table, (2) Rules for Salt Formation, (3) Key to All the Equations Involving Any Element and Compounds. The index and glossary defines 99 of the commoner chemical terms.

In general, the author has fulfilled his purpose well. There is an abundance of illustrative equations and an abundance of practice material in the exercises at the ends of the chapters.

The discussion of the periodic system in the first chapter is excellent up to the last paragraph on "atomic structure." If the student had sufficient background to get anything out of this paragraph he would not need so elementary a treatment of the preceding part. The previous elementary treatment is perhaps what is needed so this paragraph might just as well be left out.

In Chapter II we find per cent composition calculated from the formula by means of the old style proportion of dots. This form is perhaps one of the most pernicious causes of confused thinking in all mathematics, and should be completely abolished; the fractional form of proportion is much less subject to error. On page 55 are found the terms binary and ternary compounds. These two terms are superfluous to a knowledge of chemistry and should also be relegated to the trash heap. The student is overwhelmed with necessary terms; why burden him with those that are not needed?

Chapter IV on oxidation and reduction should also have been presented from the point of view of gain and loss of electrons. This point of view is gaining in favor. Also there is too much stripping the reactions of the ions and elements that are not oxidized and reduced. In practice the student meets the problem in terms of complete compounds rather than ions.

It will appear that the adverse criticisms are mostly on minor points. It may then be rightly concluded that the book on the whole is well gotten up and serves its purpose excellently.

O. L. BRAUER
STATE TEACHERS' COLLEGE,
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Annual Survey of American Chemistry. Volume III. July 1, 1927–July 1, 1928. Edited by CLARENCE J. WEST under the auspices of the Division of Chemistry and Chemical Technology of the National Research Council. Published for the National Research Council by the Chemical Catalog Co., New York, 1928. 395 pp. 13 × 21 cm. $3.00.

The publication of the third volume is a strong confirmation not only of the continued need for such a resumé of American research, but also positive evidence of the favorable reception that has been accorded the two previous issues.

The present volume contains 46 chapters and 395 pages, which is comparable with the 49 chapters and 415 pages (in-

cluding index) of the preceding survey. The names of 53 well-known chemists appear in the list of authors, 22 of whom assisted in the preparation of Volume II.

The survey in general follows the lines of the preceding issues though, to accommodate additional important fields, the following chapters have been added:

Lead; Beryllium in connection with Magnesium; Zinc; Nucleic Acids; Foods; Soils and Fertilizers; Insecticides; Lime and Gypsum; Gaseous Fuels; Cellulose and Paper; Paint and Varnish.

On the other hand, the following subjects found in Volume II are omitted from Volume III:

X-Ray Examination of Materials; Electro-Organic Chemistry; Photochemistry; Inorganic Salts; Common Earths; Microchemistry; Stereochemistry; Copper; Nickel; Proteins; Glass.

The reviewer would suggest that chemists could, with profit, read the volume as a whole and not merely the chapters in which they are especially interested. Such a perusal would aid in obtaining a better perspective, which most of us need, of the many fields of chemistry, and to such a reader there are interesting items on every page. For instance, one might well imagine the comments as well as astonishment of Berzelius on learning that ethyl lactate can be synthesized, starting from cyanamide by a nitrogen fixation plant at Niagara Falls.

As was said in a previous review, "we owe a debt of gratitude to the research council and the staff of editors for its able and painstaking work in presenting to American chemists this convenient and noteworthy survey of the year's literature."

F. B. DAINS
UNIVERSITY OF KANSAS,
LAWRENCE, KANSAS

Introduction to Modern Physics. F. K. RICHTMYER, Professor of Physics at Cornell University. First edition. McGraw-Hill Book Co., Inc., New York City, 1928. xv + 596 pp. 169 illustrations. 23 × 14.5 cms. $5.00.

The purpose of this book is "to present such a discussion of the origin, development, and present status of some of the more important concepts of physics, classical as well as modern, as will give to the student a correct perspective of the growth and present trend of physics as a whole." In order to construct the proper background and to develop a fitting perspective for the two great problems in modern physics, (1) the reconciliation of the quantum theory and the wave theory of light, and (2) the structure of matter, the first three chapters are devoted to the historical development of physics as divided into three periods, the earliest period of simple accumulation of data, the period of experimental methods, and the period of "classical" physics. The treatment of the present period of modern physics (since 1887) is concerned with modern developments and the part played by each in determining the theoretical atomic structure of matter. Each phase, such as the photoelectric effect, the quantum theory, series in line spectra, x-rays, the Bohr theory of the atom with its modifications, and radioactivity, is developed briefly from its origin to its present status.

This book should be welcomed as a text for class use by advanced students in physics. "The purpose of this book is, frankly, pedagogical," being based on lectures given in a course by the author. For advanced students in chemistry to whom developments in interrelated fields of chemistry and physics are of vital interest, it should serve as an admirable reference, numerous points of contact in the two fields being fully discussed, as illustrated by the chapter on the arrangement of electrons in atoms, dealing with static and dynamic atom models. For those with only an elementary knowledge of physics, who, from a cultural or academic point of view, desire to obtain a bird's-eye view of the field of modern physics, this text should prove adequate. In fact, the author has helped meet the long-felt need of presenting in the English language to the non-specialist in the particular fields discussed, a lucid, understandable, com-

posite resumé of the work being done by present-day physicists, without entangling the reader in the meshes of mathematical operations and symbolism, the only mathematical requirement being a knowledge of elementary calculus.

The text is very readable, the style clear and smooth, the development of each subject logical. The facts presented are reliable, authoritative, representing the last word to date in the field of physics discussed.

The book is remarkably free from mistakes; such errors as were noted would lead to no confusion or ambiguity.

CHAS. G. EICHLIN
UNIVERSITY OF MARYLAND
COLLEGE PARK, MD.

High School Chemistry. W. M. MASTERS AND L. P. FLOYD, Professors of Chemistry, North Texas State Teachers College. The Southern Publishing Company, Dallas, Texas, 1927. xvi + 500 pp. 166 illustrations. 13 × 20 cm. $1.60.

Setting before themselves four objectives, the authors "have accentuated in the text the following features:

1. A clear presentation of chemical principles.
2. The use of theory of atomic structure to explain chemical phenomena.
3. Chemical history for its cultural and humanizing value.
4. The acquisition of knowledge of practical value.
5. A special stress on the fundamental of the science."

Although the order of presentation of the elements does not differ greatly from the average text, the first chapter challenges one's attention. On the theory of the authors that "through radio and popular science publications, the student is possibly more familiar with electrons than with atoms and molecules," electrons are introduced in the first chapter, with three pages of explanation. A question at end of first chapter states: Aluminum in combination is designated by Al^{3+}; oxygen by O^{2-}; explain. In the first two chapters, covering twenty pages of text, atomic weights, molecular weights, atomic structure, methods for determining molecular weights of compounds from the formulas; percentage composition, law of definite proportion, balancing of equations and the four varieties of chemical change have been taken up. Following chapters of the text presuppose that a great deal of this material has been pretty well mastered. Given three or four weeks, this material could be well taught, with a large amount of supplementary work, but, to the reviewer's mind, it would kill the average student's interest in chemistry. Hurriedly done, even with the explanation of taking it up later, it would give the student a wrong impression of the exactness of chemistry as a science.

Oxidation by loss and gain of electrons follows in chapter 3 immediately after explanation of ordinary oxidation. With the background of experience of the authors and some chemistry teachers, explanation of one page is sufficient, but a high-school student needs a background of more than 38 pages of chemistry text to make it clear. A large proportion of equations of the first 200 pages are explained in terms of electrons. Following the chapter on ionization, little reference is made to electrons in the text; questions at the end of some chapters recall their use. Some of the modern theories of atomic structure are given at the end of the last chapter. Several electrolytic processes are discussed at length before the study of ionization and electrolysis is made.

All of the ordinary types of problems have been covered by the end of chapter 6. Although problems are listed under ten distinct types, no mention is made of solving for liters of a gas by inspection or by use of 22.4 liters in place of gram molecular weight. The book like most high-school texts is lacking in problems at the end of chapters. The reviewer has found that only through constant drill are problems instilled into the student's mind as a permanent possession.

Naming of several common acids and salts is introduced in the chapter on hydrogen, as is the electromotive series. The chapter on the gas laws (chapter 6) is particularly well presented for high-school students and includes some types of problems not usually found in high-school texts. An unusual order is followed in presenting chapters on valence, hydrochloric acid, sodium hydroxide, and chlorine. The chapter on valence is exceptionally well handled. Sixty pages of organic chemistry follow chapters on carbon and precede the study of the metals. Unusual space is given to graphic formulas for organic compounds. In view of the shortness of the chapter on colloids and its present-day importance, it does not seem best to the reviewer to place it next to the last chapter, where lack of time may cause it to be omitted.

It is generally conceded that the historical viewpoint is not of interest to high-school students. The authors have stressed historical facts and have succeeded in doing it well. Twenty-three cuts of famous chemists are shown.

Practical recitation experiments, generously interspersed through the first part of the text are valuable aids to the busy teacher, and it would seem worthwhile to extend them throughout the text. Paragraph sections are numbered and many references are given to earlier and later explanations. Concise summaries are found at the end of each chapter, and important words and statements throughout the text are emphasized by bold face type. Line drawings are well executed and the halftone illustrations are on the whole clear. A good grade of paper, good type, and binding have been used.

This book should have a strong appeal to teachers of college preparatory classes, classes of exceptional ability and as a supplementary text where several are used. Any teacher interested in the development of chemistry from the electron standpoint should examine the text.

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The Handwriting on the Wall. A Chemist's Interpretation. ARTHUR D. LITTLE, Ch.D., Little, Brown, and Company, Boston, Mass., 1928. viii + 287 pp. 13.5 × 20.5 cm. $2.50.

The book consists of 12 essays and lectures prepared for specific purposes and here edited and arranged in a coördinated manner with the general objective of emphasizing the enrichment of the common welfare by the creative power of research, especially along chemical lines.

To those who have listened to the addresses or have had the essays in leaflet form, this assembly in attractive binding will be especially appreciated The topics, as handled by Dr. Little, are both inspirational and informational; the former without exaggeration and the latter with fidelity to scientific facts. The book is especially commended to those who wish to secure up-to-date information expressed in common terms which they can readily comprehend and free from technical embellishment which for the average reader would be meaningless. As an adjunct to chemical education in this highly important field the work is to be highly commended. Here is illustrated a peculiarly fortuitous combination of circumstances—a leading chemist in the industrial field, thoroughly conscious of the significance of chemical research in the present and potential advancement of human progress, a willing and enthusiastic writer in terms of universal comprehension. This is a real accomplishment and of special value as an educational medium.

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Colloid Symposium Monograph. Vol. VI. Edited by HARRY B. WEISER, Professor of Chemistry, The Rice Institute. The Chemical Catalog Co., New York City, 1928. 346 pp. 15.5 × 23 cm. $6.50.

This volume contains the twenty-five papers delivered at the Sixth Colloid Symposium held at the University of

Toronto, Toronto, Ontario, Canada, June 14, 15, and 16, 1928. One-third of the papers were given by colloid scientists outside of the United States, thus indicating the international character of this symposium in contrast to the previous ones. As a summary of the recent advances in the field of colloid chemistry, it will be an inevitable addition to the library of all colloid specialists, while to chemists in other fields it will prove a valuable supplement.

The titles and authors of the papers follow:

1. "Living Matter," Sir William B. Hardy.

2. "Electrical Relations at Surfaces, the Spreading of Liquids, the Thickness of Surface Films and the Drop Weight and Ring Methods for the Determination of Surface Tension," William D. Harkins.

3. "Surface Conductance," David R. Briggs.

4. "The Effect of Adsorbed Water on the Electrical Conductivity of Powders," F. B. Kendrick and F. J. Giffen.

5. "The Activity and Adsorption of *p*-Toluidine in the Surface of Its Aqueous Solution," J. W. McBain, W. F. K. Wynne-Jones, and F. H. Pollard.

6. "Adsorption of Sodium Oleate at the Air-Water Interface," M. E. Laing, J. W. McBain, and E. W. Harrison.

7. "The Adsorption of Methylene Blue by Lead Sulfate," Wilder D. Bancroft and C. E. Barnett.

8. "The Effect of Temperature on the Coagulation of Copper Colloidal Solution," E. F. Burton and Beatrice Reid Deacon.

9. "The Structure of Softwoods as Revealed by Dynamic Physical Methods," Alfred J. Stamm.

10. "Fractionation of Diphtheria Antitoxic Plasmas," P. J. Moloney and Edith M. Taylor.

11. "Cataphoresis of Blood Cells and Inert Particles in Sols and Gels and Its Biological Significance," Harold A. Abramson.

12. "Methods of Studying the Surfaces of Living Cells with Especial Reference to the Relation between the Surface Properties and the Phagocytosis of Bacteria," Stuart Mudd, Balduin Lucké, Morton McCutcheon, and Max Strumia.

13. "The Rôle of Hemoglobin in the Blood," A. Baird Hastings.

14. "The Effect of Emulsification in the Peptic Synthesis of Protein," H. Wasteneys and H. Borsook.

15. "Emulsions and the Effect of Hydrogen-Ion Concentration on Their Stability," John C. Krantz, Jr., and Neil E. Gordon.

16. "New Microscopic Methods in Connection with the Problem of Vulcanization," E. A. Hauser, H. Miedel, and M. Hünemörder.

17. "Preparation and Properties of Aqueous Rubber Dispersions," H. L. Trumbull.

18. "Studies of Organophilic Colloids," G. S. Whitby, J. G. McNally, and W. Gallay.

19. "The Influence of Electrolytes and Non-Electrolytes upon the Optical Activity and Relative Resistance to Shear of Gelatin Systems," J. R. Fanselow.

20. "Influence of Gel Structure upon the Technology of Smokeless Powder Manufacture," Fred Olsen.

21. "Grain Growth in Silver Halide Precipitates," S. E. Sheppard and R. H. Lambert.

22. "The Uniform Distribution of Catalysts throughout Porous Solids," Harry N. Holmes and Robert C. Williams.

23. "The Development of the Ultracentrifuge and Its Field of Research," J. B. Nichols.

24. "The Study of Hydration Changes by a Volume-Change Method," H. A. Neville and H. C. Jones.

25. "Adsorption of Ions and the Physical Character of Precipitates," Harry B. Weiser and G. E. Cunningham.

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